AIRCRAFT AND MISSILES MANUFACTURING

DECEMBER 1958

A CHILTON PUBLICATION

DESIGN
PRODUCTION
PROCUREMENT

$$\text{PACE} = \frac{[\text{NO. ASSIGNED} \pm \text{LOANS} - (\text{IDLE} + \text{OUT OF AREA})] \times \text{EFFORT RATE}}{\text{NO. ASSIGNED} \pm \text{LOANS}} \times 100$$

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Tomorrow's need is today's challenge at..

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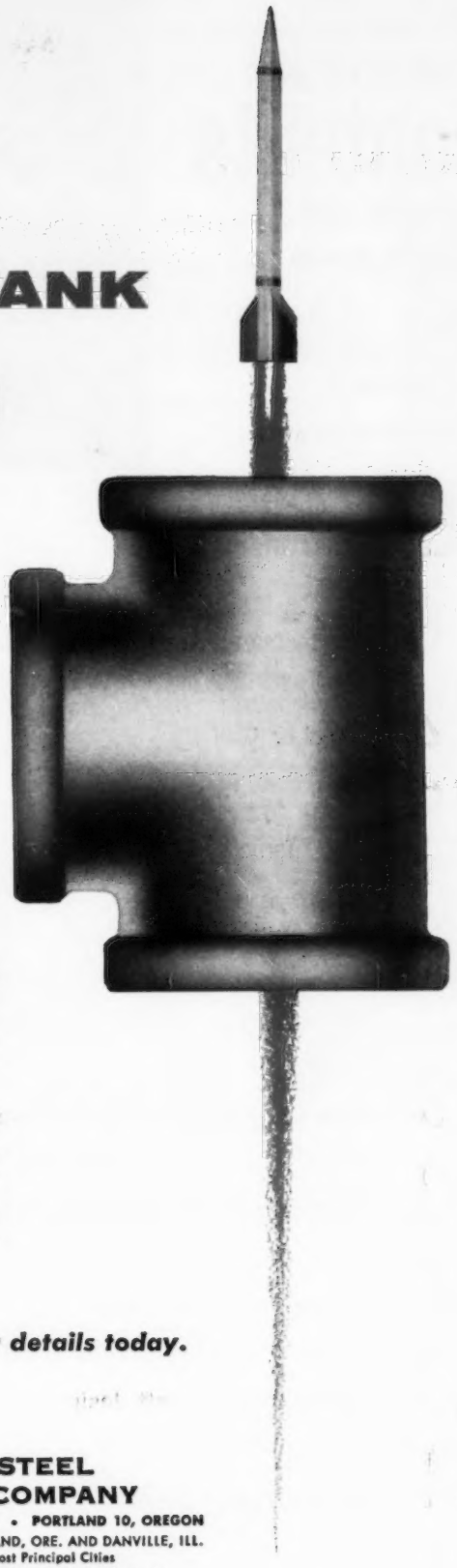
FROM STORAGE TANK TO GUIDED MISSILE



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DECEMBER 1958

VOLUME 1, NUMBER 12

DESIGN
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A CHILTON PUBLICATION

THE COVER STORY

The tempo of the human pulse is used as a basic measure of well-being for the human system. The overall tempo of a working group is likewise vital to the production manager. Northrop's Performance And Cost Evaluation program, abbreviated PACE, has been designed to feel the pulse of production. It is based on the standard industrial engineering yardstick, of the effort expended by a man walking 3 mi/hr. Reflecting daily the effort of a working group, PACE is furnishing the answer to the recurring question—how are we doing?

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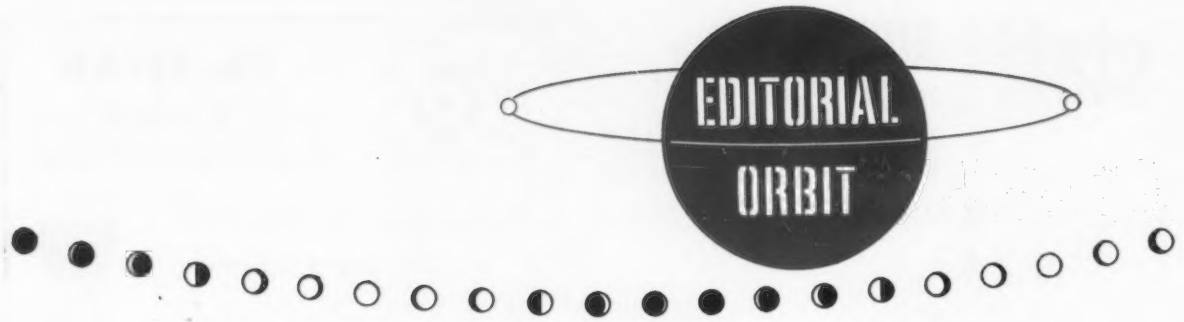

back to the drawing board with integration

Once again we're pounding our fists on the desk, striving for close teamwork within the aircraft and missile industry. This time we're talking about technological progress through coordinated effort.

Let's take a quote from A. B. Higgins, manager of Military Relations, Convair . . . "I can say that those scientists and engineers preparing weapon systems on paper feel much more confident in the early stages of preparation, than they do as subsequent months roll by and the product starts into initial testing. The State of the Art, today, is our number one problem. We don't have all of the answers. Therefore, we must start production parallel with engineering design, tooling, fabrication, and assembly, without a period of time set aside within our schedule flow to prove their quality." . . . Mr. Higgins made this statement before a large group of executives at the National Machine Tool Builders' Association 57th Annual Meeting.

As this points out, we have to have the product before we can measure its reliability. But, it is strongly felt around the industry that if there is constant teamwork in the beginning phases of a program, we can achieve a reasonable degree of reliability by the interchange of experience. Many people in Government have stated that this type of programing has cost the taxpayer considerable money without any benefit. It's not true. Let's think of the valuable information that has been left behind. Our experience level has benefited.

Let's see what happened after an areodynamic missile program was cancelled.

A modification of the cancelled engine, was used to put up the Explorers. Booster engine advances were incorporated in other missiles. Its aerodynamic configuration has been proved for long-range high-altitude flight at supersonic speeds. This will be used for the chemical bomber. Piggy-back, missile-booster combinations were shown to be aerodynamically sound. New materials were developed that would provide high strength and that would be resistant to heat, yet, at a minimum weight. A new manufacturing process was developed to pre-stretch stainless steel sheet and give it a low temperature heat-treatment to obtain the required strength.

These are just a few of the items that were achieved through a coordinated effort. In technological terms we gained a great deal, because the company involved has been a proponent of coordination among its departments to achieve a high degree of reliability with lower costs.

Editor

Photograph courtesy General Electric Co.

magnesium . . . missiles . . . and manufacturing

Many magnesium alloys have the theoretical properties that missile designers need to give form and shape to their high-flying ideas. It's no wonder so many missile designers are relying on magnesium castings to keep their buzz birds trim and tough with a more-business-and-less-baggage punch.

But before these magnesium-inspired ideas can graduate from the drawing board to "operational capabilities," they must go through that difficult stage known as "production." Here's where Rolle can take over for you. Design your magnesium castings as complicated as the application requires, and we'll worry about the production.

Our experience in missiles covers sand, permanent mold, shell, and investment castings of magnesium and aluminum . . . from some of the smallest to *the* largest magnesium casting made to date. In these castings is realized the full potential of the materials used and the highest level of dimensional accuracy.

For missiles with more wallop per unit weight, use magnesium alloys. For magnesium castings that meet your requirements exactly, make the most of Rolle's unrivalled experience in the field. A special Engineering Manual to help you design and specify aluminum and magnesium castings is available on letterhead request. Write for your personal copy to Rolle Manufacturing Company, 317 Cannon Avenue, Lansdale, Pa., Ulysses 5-1171.

ROLLE

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Performance And Cost Evaluation at Northrup

by E. Nolan, v.p. and general manager,
Northrup Div., Northrup Aircraft Inc.

Most experienced production executives can detect the pace or tempo of plant operations. In heavily-automated industries it is set and maintained by machines. In aircraft and missile manufacturing it depends on the performance of people with attendant intangible factors.

To study and analyze its own pace scientifically, the Northrop Division of Northrop Aircraft initiated a novel management tool and called it PACE (Performance And Cost Evaluation).

PACE is a means of measuring group effectiveness in performing an assigned task. The program is conducted and constantly improved by the Manufacturing Methods Engineering Group. It consists of measuring group effectiveness at frequent intervals and comparing it with indices such as number of personnel involved, budget realization, schedules, quality control and parts shortages. This provides a tool with which supervisors can determine the effectiveness of their organizations at any given time.

How PACE Works

Trained observers first conduct a two-week basic study of the organization to be measured. They learn the nature of the group's task, the number of personnel involved, man-hours budget, schedules, and any problem areas. The observers tour the organization's area several times a day at random hours, using different routes of approach. Each time they total the number of personnel idle or not working at assigned tasks, and those out of area. Through experience and training, they are able to determine, by observation, the group's effort output. The effort output is rated by percentage of optimum normal effort, i.e., the known, average sustained effort of an efficient worker.

This data is converted to a PACE Measurement Index by applying the following formula (for factory-type activities):

$$\frac{[\text{No. assigned} \pm \text{loans} - (\text{idle and out-of-area})] \times \text{effort rate}}{\text{Number assigned} \pm \text{loans}} \times 100$$

The result equals % PACE

This is plotted on a chart in weekly increments. It is the basic index showing the trend of group effectiveness. The goal for each organization is to bring the PACE line up into the "control area" of the chart. This control area ranges from 85 to 100 per cent of optimum normal effectiveness. (Northrop investigations indicate that 55 to 65 per cent is common in the airframe industry. Similar lags in efficiency may be found in other industries where individual production rate controls are difficult to apply). The beginning point of the PACE line, however low, carries no immediate penalty; what matters most is the trend of the line and the rate of change.

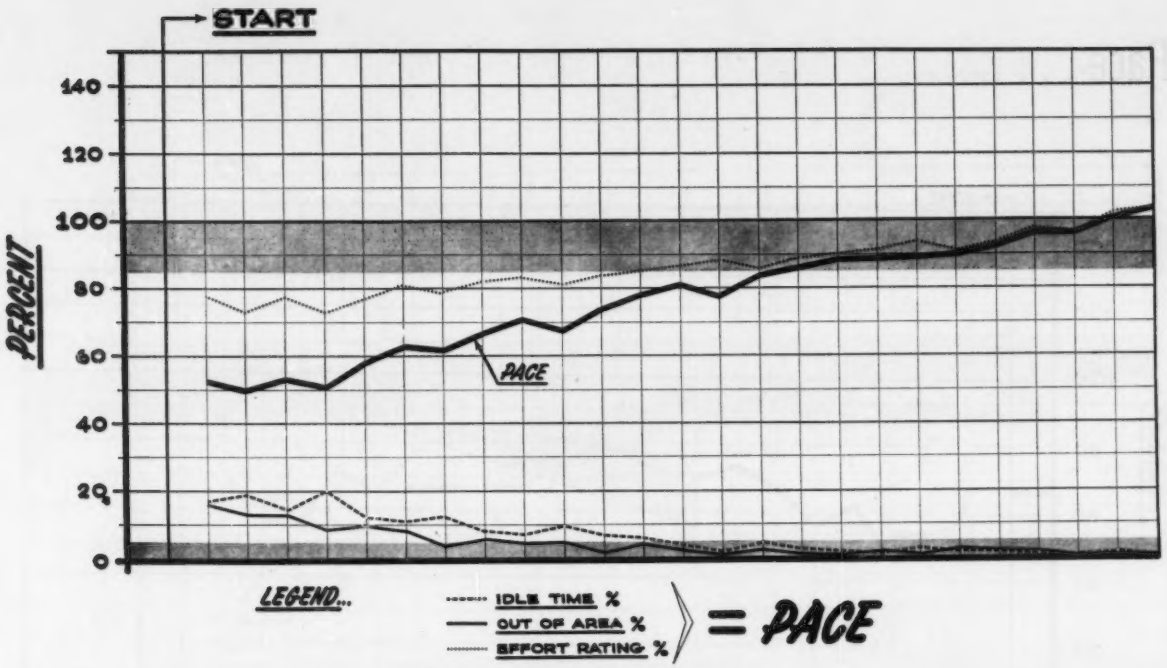
When the PACE line is established, a corridor leading into the control area at a selected target-rate is also charted. The group is expected to keep the line within this corridor until it reaches the control area.

Other Indices

The PACE line is only a measurement of the diligence with which an organization applies itself to the job. Other indices are necessary to round out the picture which this program gives to supervisory personnel.

Personnel Index: This is the ratio of department population for the current week as compared to a base week. As PACE improves, fewer people are needed to do a given task, all other factors being equal. Hence, as the PACE line goes up, the personnel index should go down.

Budget Realization Index: This index is computed from the ratio of earned hours to actual hours spent (with the learning curve taken into account). As the PACE line goes up toward the control area, the budget realization index usually will rise.



Basic PACE index and its components.

Schedule Index: This is the ratio of actual production to scheduled production. Being ahead of schedule is just as unsatisfactory as being behind, and creates its own set of problems. Schedule realization is controlled by varying the number of personnel.

Quality Index: This is established from a formula developed by the quality control department. From this Program, Northrop learned that quality increases as PACE increases. Thus far, no point of diminishing return has been established for the PACE/quality ratio.

Shortage Index: Shortages affect PACE. Personnel running short of parts tend to slow up to "stretch out" the work so as not to be completely idle. Because of the peculiarities of aircraft production, an operation normally can stand a small number of shortages without PACE being affected noticeably. The shortage index is a ratio of the number of shortages compared to the total number of different parts that should be available. Since this ratio is small, it is multiplied by a shortage ratio so that "out of control" occurs when the index number is over five.

Procedure for Measuring Office PACE:

The major differences between office and factory activity are taken into account through two major modifications.

1. Normal out-of-area time is not computed as a penalty. Many office functions require that personnel be out of the area frequently.

2. Physical inactivity is not necessarily computed as idleness. The worker may be concentrating on a problem relating to his job. His group is always given the benefit of the doubt.

Office activities are listed in four major categories: mental, manual, visual, and oral. No attempt is made to evaluate pure mental activity. Time spent in mental activity not accompanied by manual, visual or oral activity is a very small percentage of the total effort. While this percentage is not precisely measureable, a reasonable estimate is possible.

Effectiveness of office groups is measured in 15-point increments (85 to 100 per cent, 70 to 85 per cent, etc.), rather than by the point-by-point method used in factory group evaluation. However, point values are required for plotting.

These are determined by mean averages.

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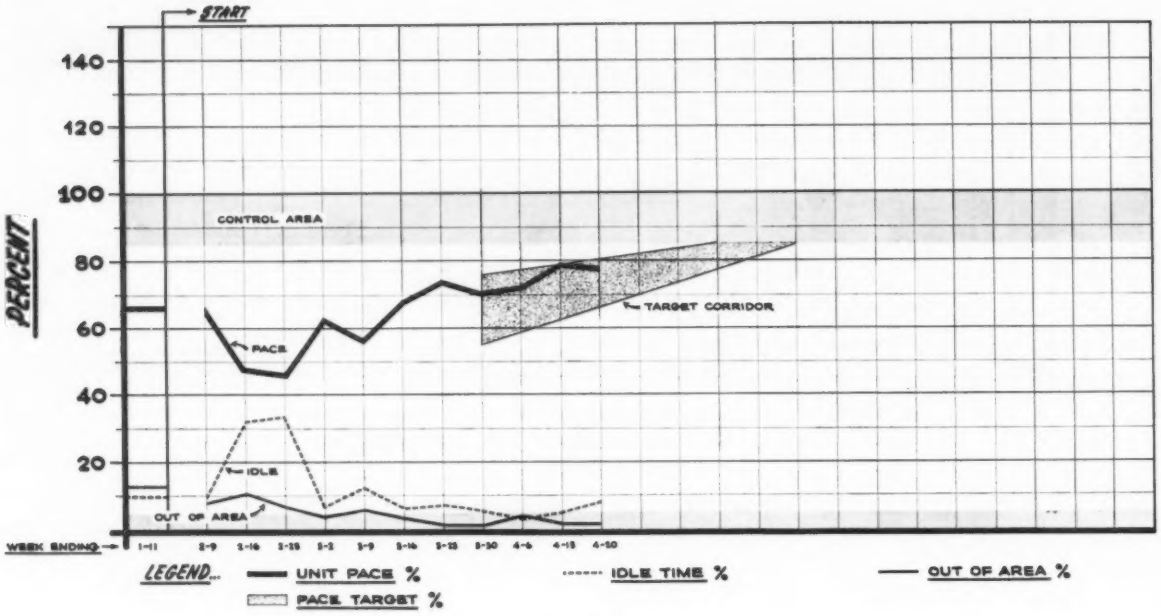
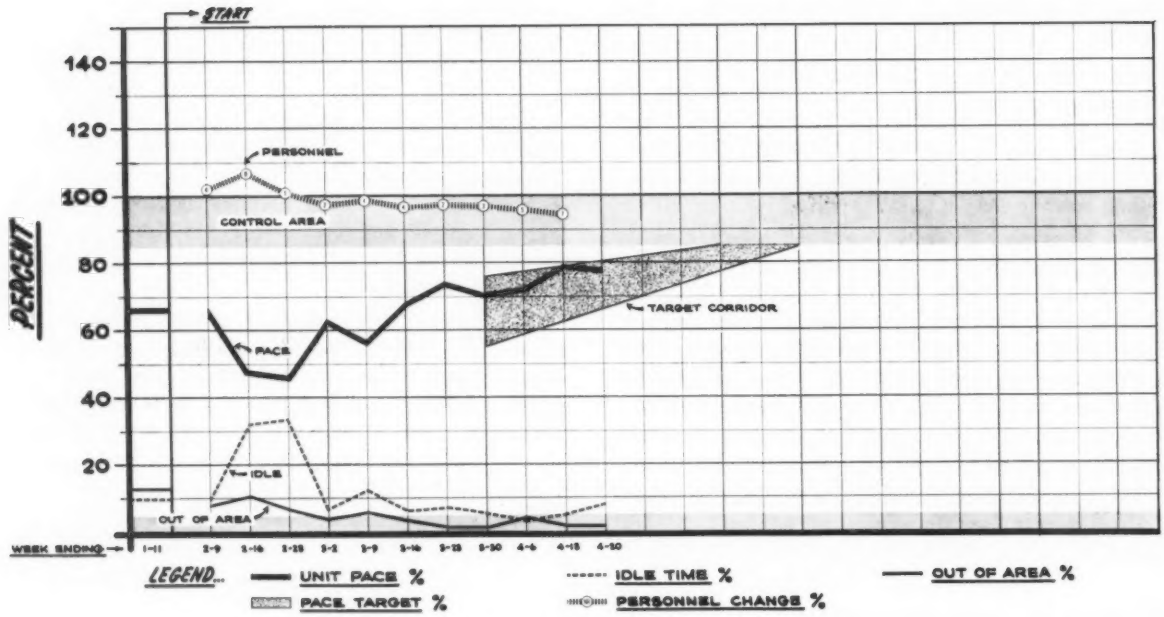
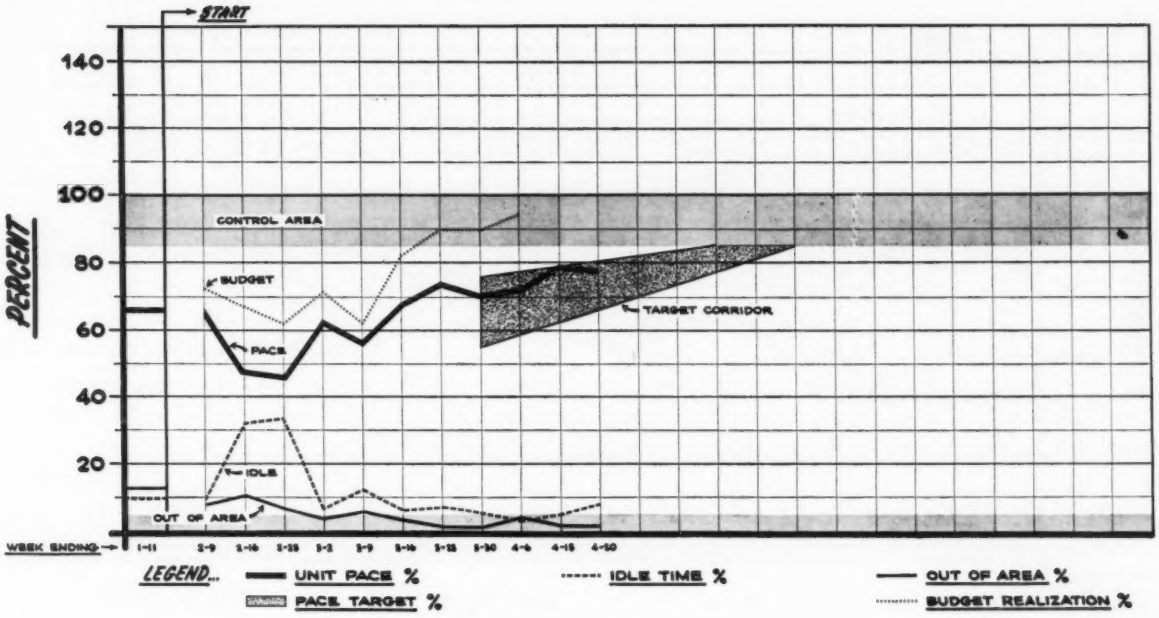
Pace . . . continued



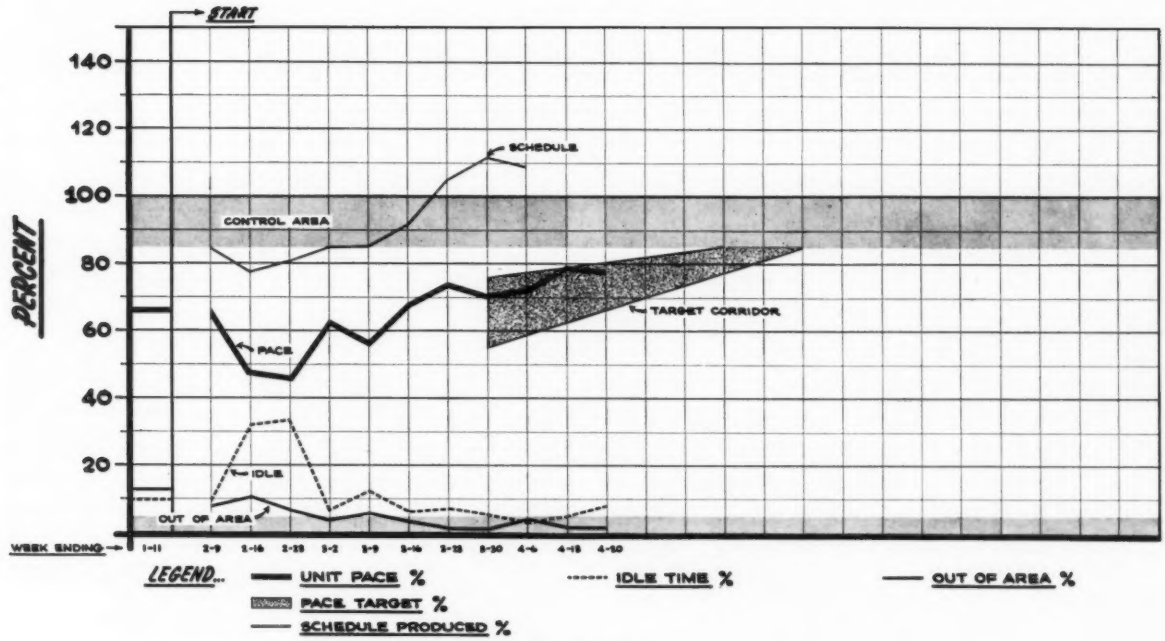
Target corridor.



Personnel change index.



Budget Realization index.



Schedule index.

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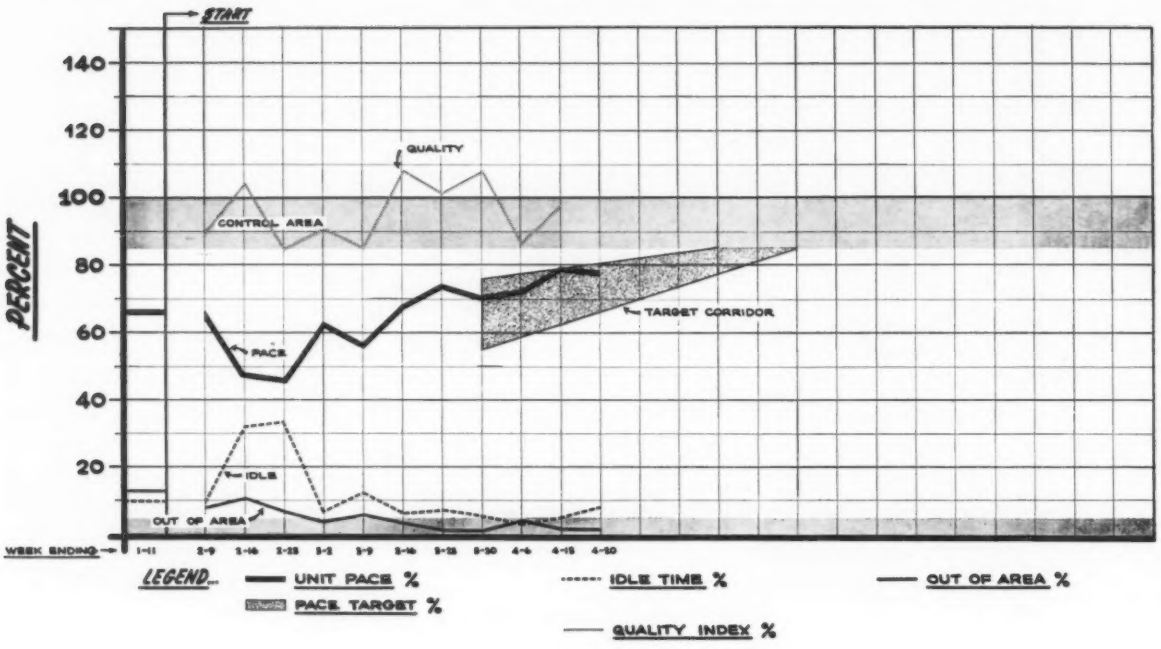
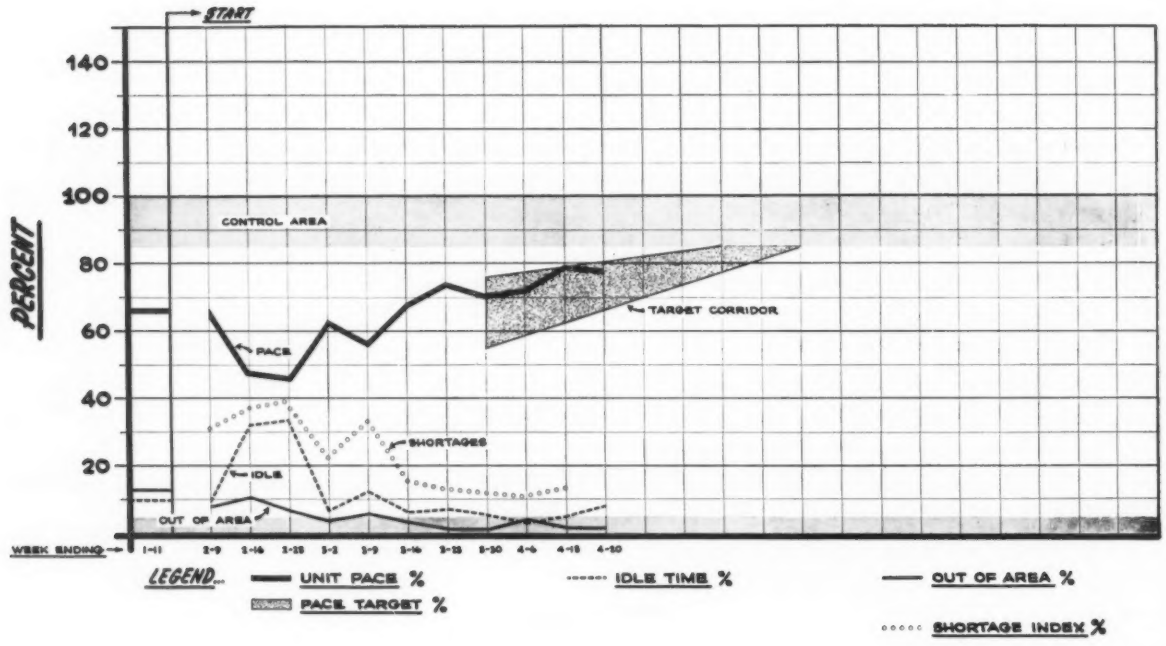
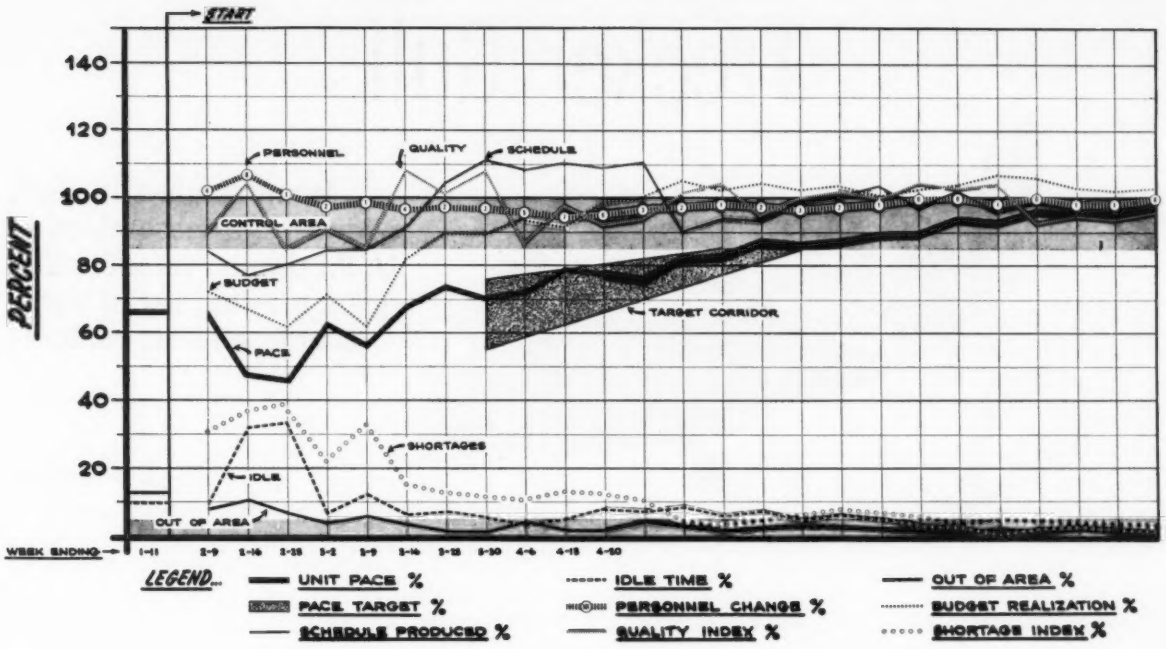
Pace . . . continued



Quality index.



Shortage index.



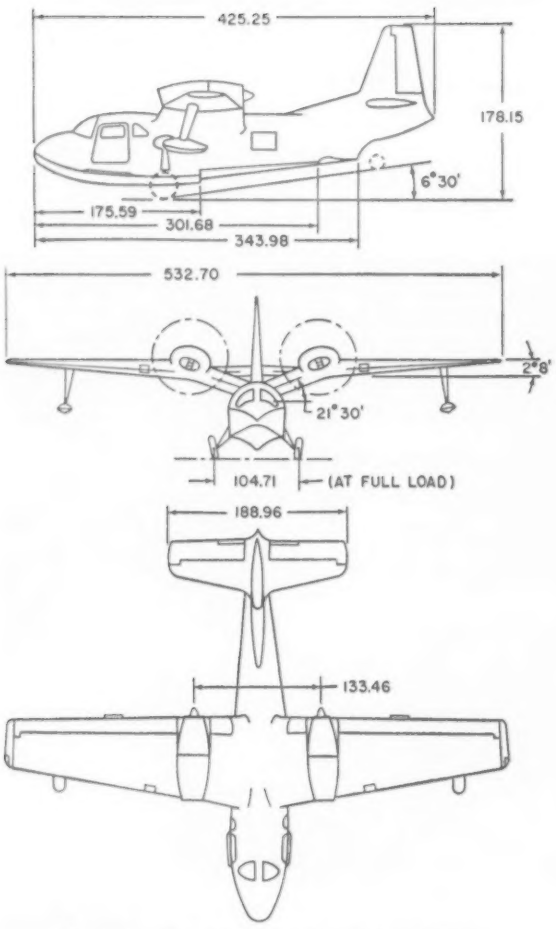
Full PACE report, showing all indices.

PACE office crew in manufacturing methods engineering group consists of two statistical clerks, an analyst, and an artist who prepares the charts. The crew tabulates and analyzes data turned in by PACE observers, and records it in chart form.

Trecker Gull

Manufactured in Italy, modified and assembled in U. S., simple, versatile Gull joins growing list of trans-atlantic aircraft ventures

by John Kevern



Three-view diagram of Trecker Gull amphibian.

GULL

PERFORMANCE

(At Maximum Gross Weight 6000 Pounds)

Cruising Speed:	
At 70 percent power (2750 rpm 21.3 in. Hg.)	161 mph at 5000 ft
At 65 percent power (2750 rpm 20.8 in. Hg.)	164 mph at 8000 ft
High speed at sea level	182 mph
Rate of climb at sea level—Two engines	1180 fpm
Single engine inoperative, prop feathered	216 fpm
Service Ceiling—Two engines	18,400 ft
Service Ceiling—Single engine (With 50 fpm climb reserve)	4100 ft
Absolute Ceiling—Single engine	5000 ft
Stalling Speed (Landing with flaps)	68 mph
Stalling Speed (Flaps and gear retracted)	75 mph
Cruising Range:	
At 70 percent power (182 HP)	at 8000 ft, 895 miles
At 60 percent power (156 HP)	at 8000 ft, 990 miles
Endurance:	
At 70 percent power (182 HP)	5.5 hr
At 60 percent power (156 HP) (Including fuel for warmup, taxiing, take-off, climb, descent and landing.)	6.5 hr
Take-off Distance (with ½ flaps) Ground run	965 ft
Total over 50 ft obstacle	1380 ft
Landing over 50 ft obstacle (with full flaps)	
Ground run	755 ft
Total over 50 ft obstacle	1410 ft
Sea level water take-off time	18 sec

AREAS

Wing Area	270.2 sq ft
Aileron Area	21.3 sq ft
Wing Flap Area	28.6 sq ft
Horizontal Tail Area	55.83 sq ft
Stabilizer Area	28.87 sq ft
Elevator Area	26.96 sq ft
Vertical Tail Area	26.95 sq ft
Vertical Fin Area	16.79 sq ft
Rudder Area	12.17 sq ft

The Gull, a high-wing, twin-engine pusher-amphibian offered by the Trecker Aircraft Corp., Division of Kearney & Trecker, Milwaukee, typifies the current trend toward transatlantic business ventures.

Major components of the Gull are manufactured by Piaggio & Co. of Genoa, Italy. Subassemblies of each amphibian are "cocooned" and shipped, in three special crates directly to Milwaukee via small freighter.

Assembly and finishing are effected by Trecker Aircraft, with the addition of American engines, propellers and instrumentation. The shipping crates are returned to Italy for re-use.

The utility and durability of this aircraft have been proven in service with the Italian Air Force in air-sea rescue and coastal patrol operations. It has also operated successfully in the bayou region in connection with oil exploration, and on the West Coast as a resort liner.

Structural Characteristics

The structure of the aircraft is aluminum alloy throughout. The stepped, monocoque hull incorporates conventional stringer and frame construction, covered with alclad skin.

L-shaped stringers are used on the sides and on the top of the hull; Z-type stringers provide the stiffness for the bottom and the deck structures.

A mid-hull, water-tight bulkhead is used as a key member separating bow from stern. This

SPECIFICATIONS

DIMENSIONS AND GENERAL DATA

WINGS	
Wing Loading	22.22 lb/sq ft
Wing Span	44 ft 5 in
Chord:	
Mean Aerodynamic	77 in
Mean Geometric	73.3 in
Dihedral:	
Wing Root	21° 30′
Outboard of engines	2° 8′
TAIL	
Horizontal:	
Span	15 ft 9 in
Incidence	0 deg
Vertical:	
Height (from Horizontal stabilizer top surface)	81.1 in

CLEARANCE DATA

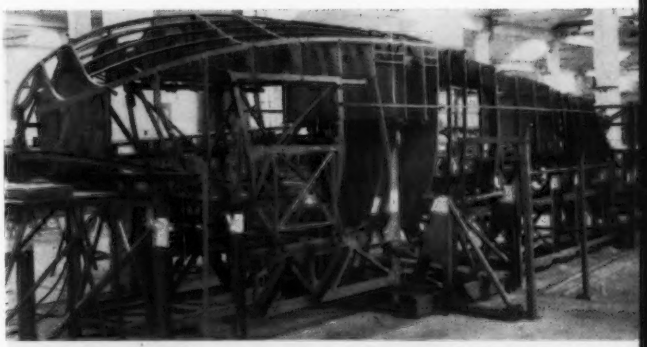
Height over highest part of aircraft. Aircraft in normal ground altitude	12 ft 7 in
Length overall	35 ft 7 in
Span overall	44 ft 5 in
Draft immersion	24 in

CONTROL SURFACE ANGULAR TRAVEL

Aileron	up 24 deg, down 20 deg
Elevator	up 27 deg, down 18 deg
Elevator tab	up 14 deg, down 18 deg
Rudder	30 deg right, 30 deg left
Rudder tab	15 deg right, 15 deg left
Water rudder	34 deg right, 34 deg left

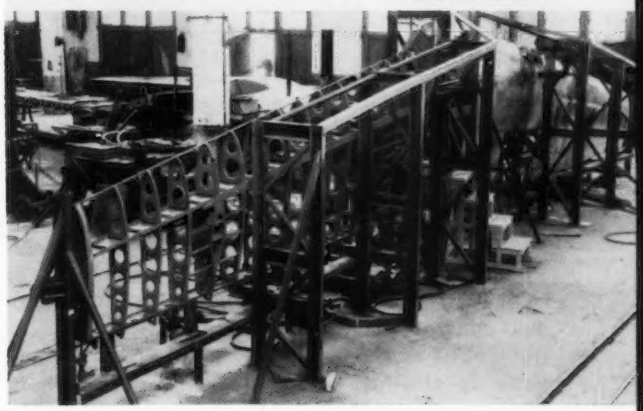
WEIGHTS

Gross Weight	6000 lb
Empty Weight	4400 lb
Useful load	1600 lb
Available weight for passengers and baggage with full tanks (190 gal)	400 lb

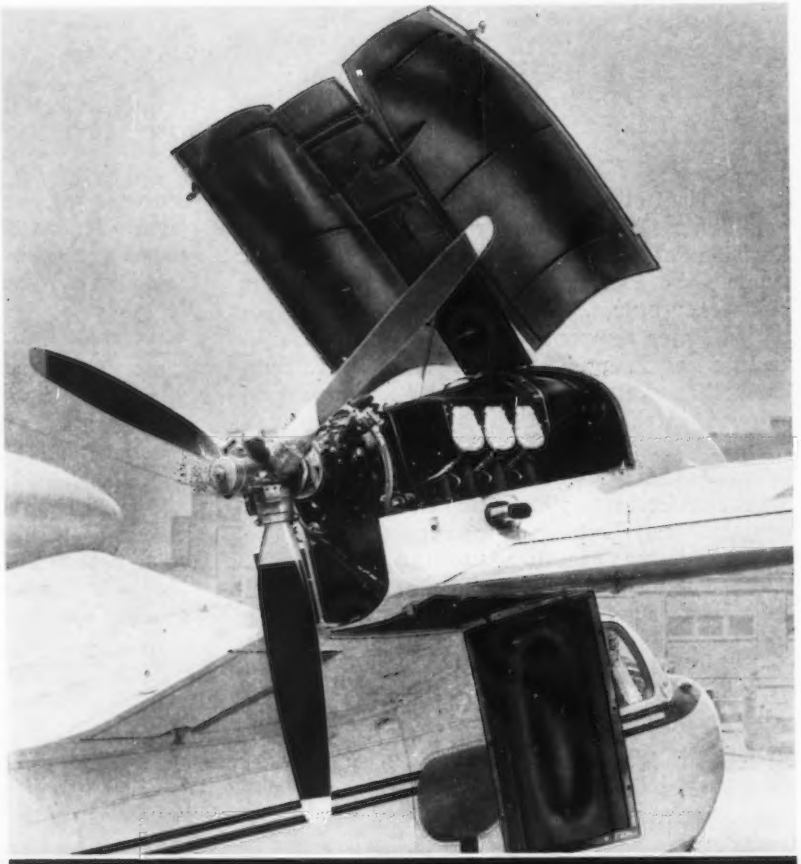


At initial stage the hull frame is manufactured in inverted position. Water-tight bulkhead seen in middle divides bow from stern.

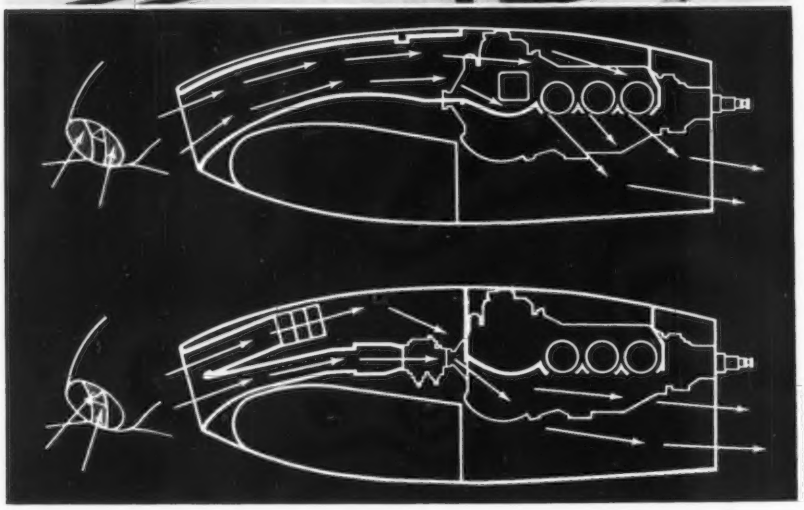
Conventional wing structure incorporates integral wing panels with canted root sections.



Trecker Gull . . . continued



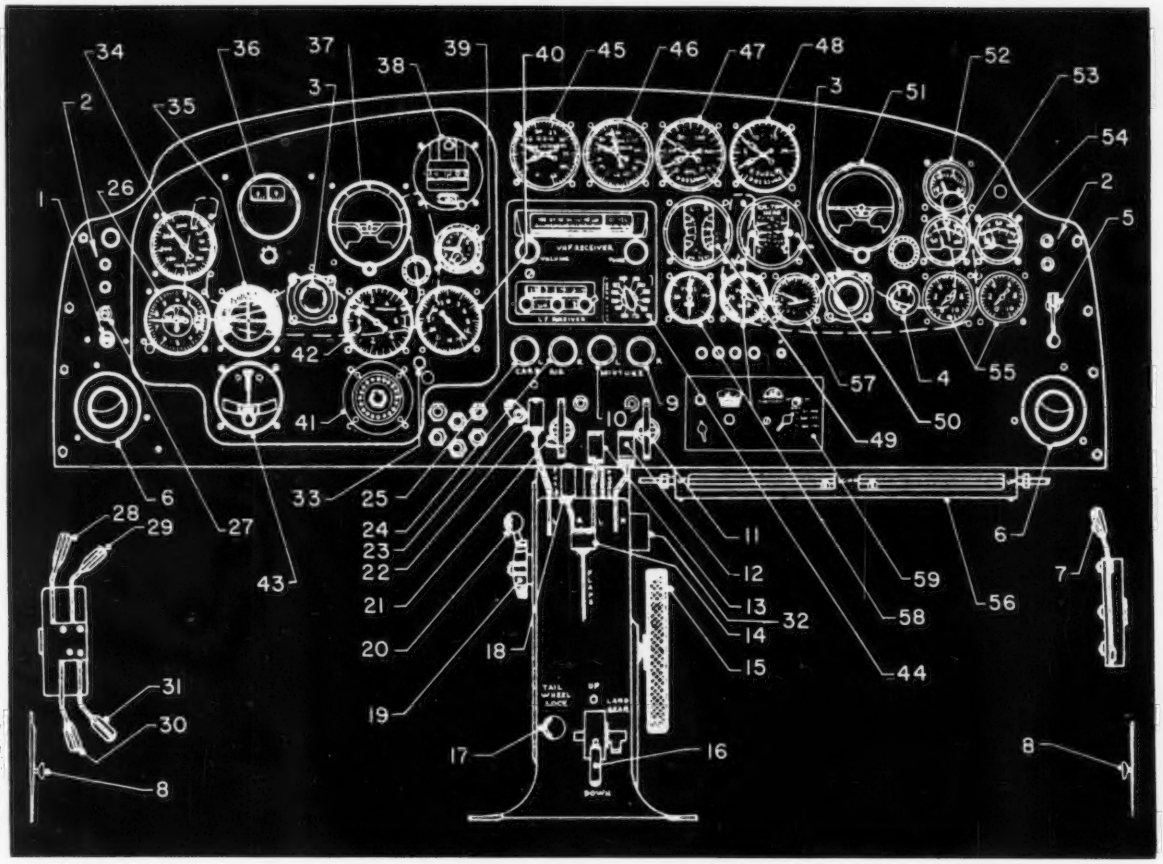
Serviceability of engines is insured through large hinged access panels both from above and below.



Engine nacelle ventilation system.

bulkhead picks up the wing front-spar fittings. Bow end houses cabin; stern half of hull accommodates luggage compartment and fuel tanks. The cabin, accessible through a large door on each side, seats two in front and three in rear. A dual control system is featured.

The characteristically gull-shaped, tapered wing is also of metallic construction. Simple structure incorporates a main and an auxiliary spar, and typical stamped ribs perforated with flanged lightening holes. Partial, spanwise stringers stiffen vicinity of engine nacelles and wing-float spar attachment areas. The canted wing-root portion of each wing is manufactured integrally with the outboard panel. Each wing is connected to the fuselage through two fittings on the main



Gull instrument-panel arrangement.

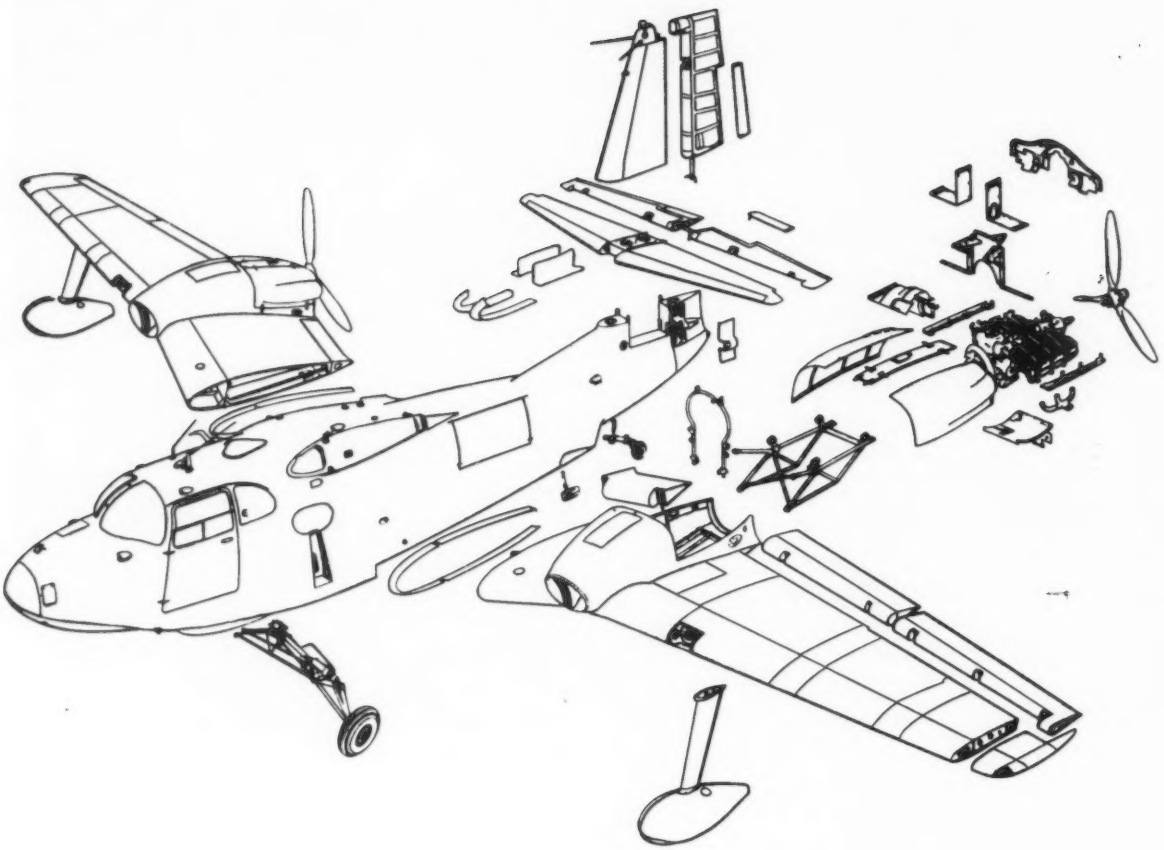
1—Engine switch
2—Headset tap
3—Control wheel axle
4—Heater control
5—Hydr. sys. Zero set
6—Cabin air inlet
7—Cabin air cond. lever
8—Hot air flow-regulator
9, 10—Mixture-control levers
11—R.E. fire extinguisher
12, 13—Propeller control
14—Flap control
15—Elevator trim control
16—Ldg. gear control
17—Tail-wheel lock
18—R.E. throttle
19—Control lever clutch
20—Parking brake
21—L.E. fire extinguisher
22—L.E. throttle
23—Ldg. gear position lamp
24, 25—Hot air to carburetors
26—Altimeter
27—Priming control
28, 29, 30, 31—Fuel management controls
32—Heater thermostat
33—Stall warning
34—Air-speed ind.
35—Landing I.L.S. ind.
36—Directional gyro
37, 51—Gyro-horizon
38—Compass
39—Clock
40—Radio-compass ind.
41—Pre-stall warning
42—Rate-of-climb ind.
43—Turn and bank ind.
44—Radio
45—Tachometer (dual)
46—Manifold press. (dual)
47—Oil press. (dual)
48—Fuel press. (dual)
49—Oil temp. ind. (dual)
50—Cylinder temp. (dual)
52—Ammeter
53, 54—Carb. air temp.
55—Vacuum gages
56—Ldg. gear pos. ind.
57—Hydr. press. ind.
58—Fuel qty. ind.
59—Radio compass

spar. Wing-panel incidence is three deg at root, and is gradually reduced, by wing warping, to one deg at the tip. Wing tips are detachable.

Power Plants

Each engine is cradled in gull-joint of wing through a false spar acting as a load-bearing structure. Four machined fittings on each false spar accommodate the tubular engine mount. Engine nacelle front is integral with wing and forms a four-ported oval intake. Two ports supply the engine-cooling air, one feeds the carburetor, and another cools the oil system.

The movable engine-cowl consists of three sections. An upper beam-type section and two



Trecker Gull... continued

chordwise-hinged door panels. The beam-type section is hinged at the front, and when swung up to expose the engine it is supported by a prop rod. Another spring-locked door on lower camber of wing provides engine access from below nacelle.

The Gull is powered by two Lycoming GSO-480-A1A6 supercharged engines of 340 hp each. The aluminum alloy, three-blade propellers are of the Hartzell full-feathering type.

Rudder, elevator, and ailerons have aluminum alloy framework covered with fabric. Fin, stabilizer, and flaps are of aluminum alloy throughout. The control system is of the conventional cable and pulley type. Teleflex transmission is used to actuate a hydraulic selector valve for operating the flaps via a lever-and-rocker system.

The advantageous location of the center of gravity has allowed conversion of the Gull from a five-place amphibian into an eight-place seaplane for resort-line flying.

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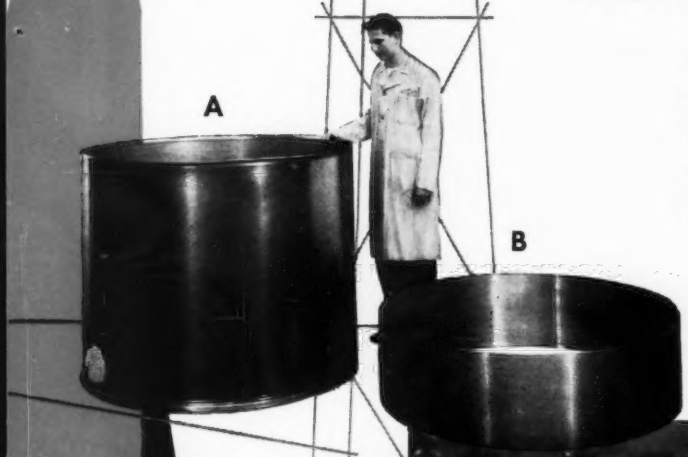
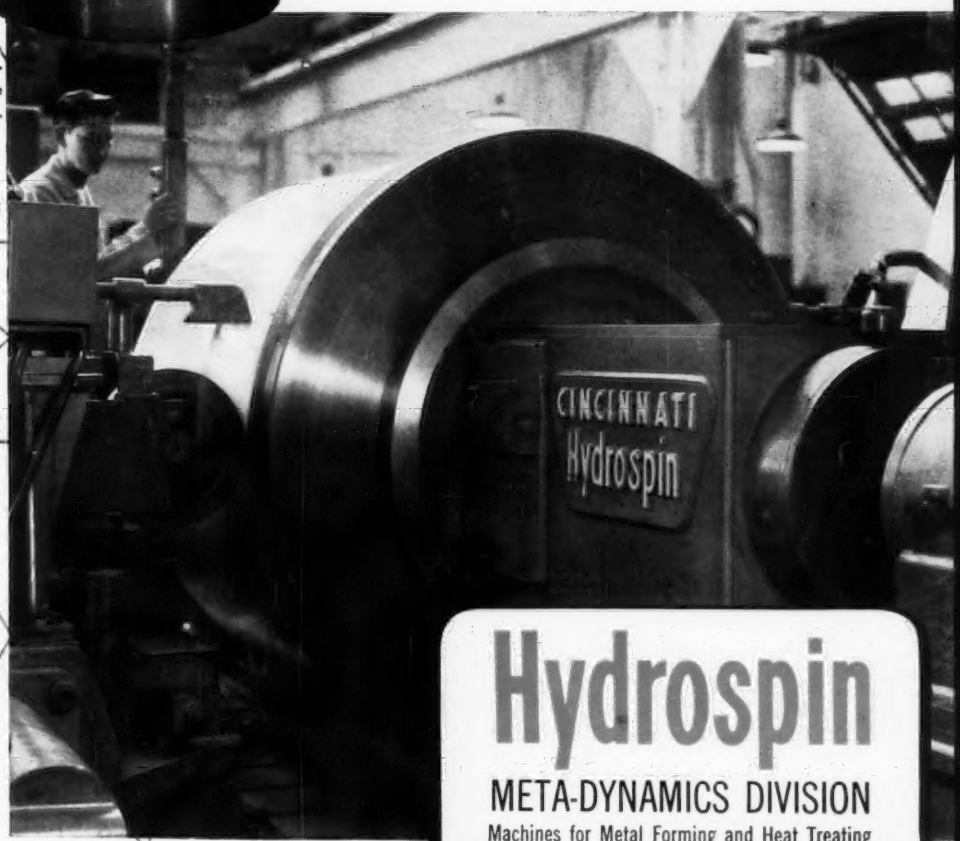
Hydrospinning makes BIG NEWS *For Producing Guided Missile Hardware*

"*Chipless Machining*" by the Cincinnati Hydrospin® offers an unsurpassed method for producing lighter, stronger, guided missile hardware at tremendous savings in materials and production time. Many types of exotic, high tensile strength alloys—ferrous and non-ferrous—which reduce weight, can be used. With low-cost tooling, parts are quickly produced to accurate dimensions . . . have fine finish . . . with increased strength, hardness and fatigue resistance.

Development work that has been conducted indicates that parts up to 98″ diameter, and larger, can be successfully Hydrospun. For full details, call in a Meta-Dynamics Division field engineer.



Part (A) is spun from preform (B)—using this double roller Cincinnati Hydrospin.



Hydrospin

META-DYNAMICS DIVISION

Machines for Metal Forming and Heat Treating

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CINCINNATI

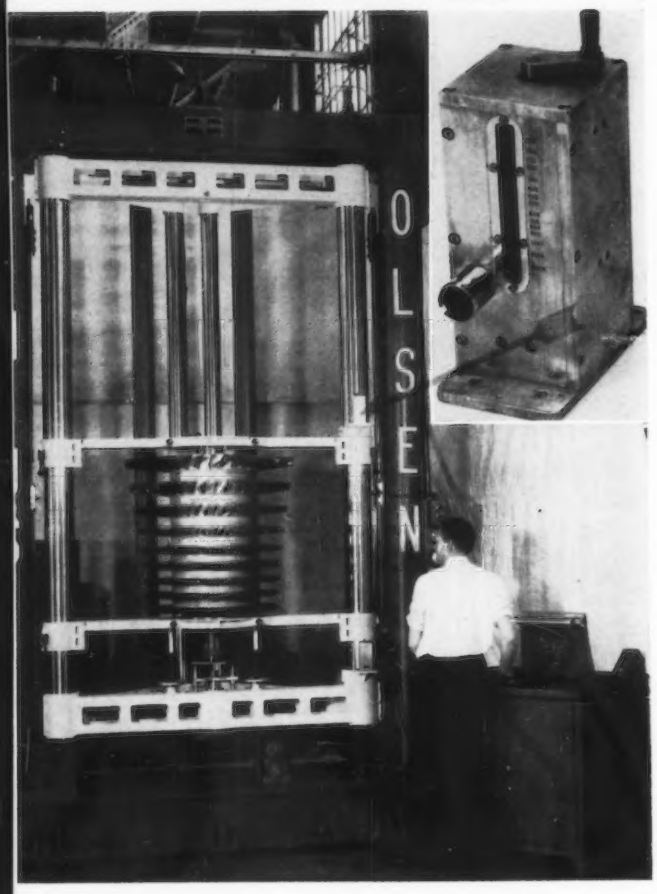
Circle 8 on Inquiry Card, page 81

vertical dynamic balancing

machine uses "controlled unbalance" to check jet engine components with extreme accuracy

by S. Peter Kaprielyan

Front view of Tinius Olsen vertical dynamic balancing machine, with J-57 compressor assembly mounted between horizontal work-support carriages. Tunable vibration pickup is shown in insert.



Dynamic unbalance is the destructive enemy of machinery with rotating parts. The high operational temperatures and speeds of aircraft jet engines make this foe potentially more dangerous. Much equipment has been devised to prevent this force from coming into play in the first place.

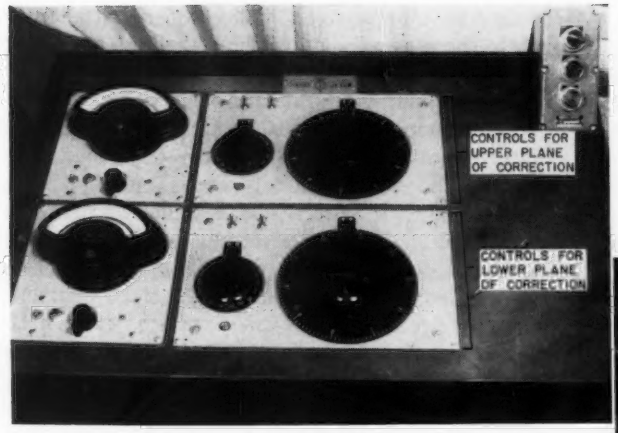
The JDV-1000 vertical dynamic balancer is one of the most advanced entries in this field; it has been developed by Tinius Olsen Testing Machine Co., of Willow Grove, Pa., producers of balancing equipment since 1870.

The vertical design pioneered in this machine minimizes errors due to mis-positioning or shifting of blades of jet engine components. As soon as the part or assembly is spun, the blades are driven into and held in proper position by centrifugal force. Each time the machine is stopped and re-started, the blades will position themselves in the same manner. This assures consistent repeat-readings.

In non-rotating static balancing machines, the blades can assume varying positions which can result in seriously inconsistent readings.

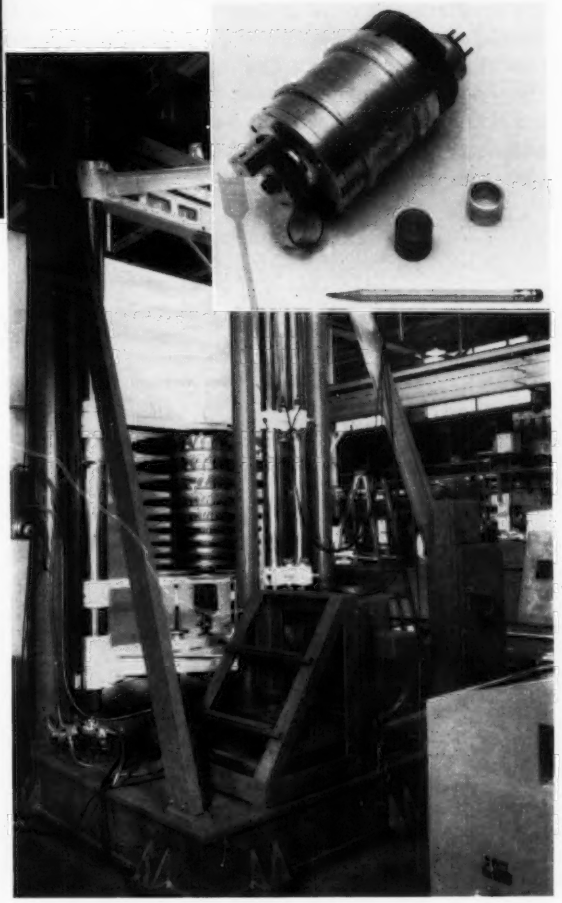
This machine can accommodate turbojet components up to 55-in. diam, 90-in. long, weighing 1000 lb. Its operating principle consists of rotating the part to be balanced in a pendulum frame, and checking vibration through a controlled unbalance.

Briefly stated, if the center of gravity of a disk does not lie in its axis of rotation, it is out of balance. Correction of its condition by



Close-up of control console shows twin differential-synchro arrangement.

Rear view of balancing machine showing both pairs of compensating synchros. Close-up of a synchro unit, with removable counterweights, can be seen in insert.



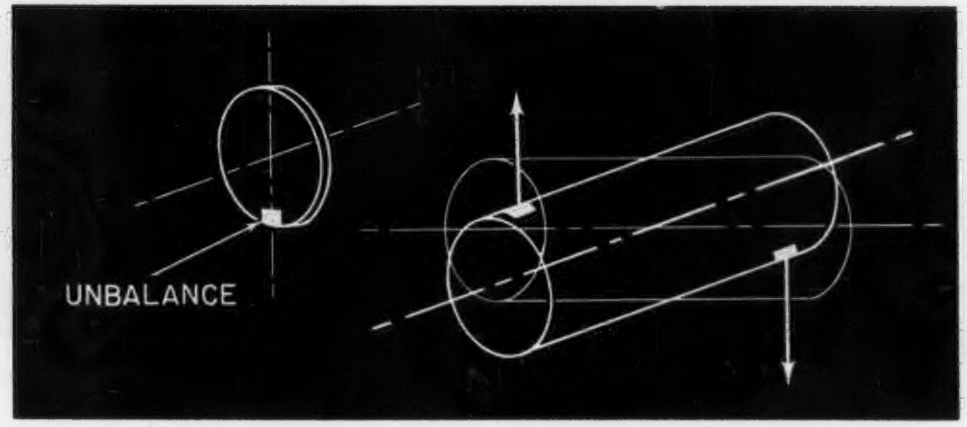
adding or removing weight, within one plane, is called static balancing. In a cylindrical body uneven distribution of weight causes it to seek its own rotational axis of inertia; variance between axes of rotation and of inertia cause eccentric loads, hence vibration. Corrective action in this case requires compensation in both end-planes of cylindrical body.

Jet engine assemblies or individual stages can be balanced on this machine to within 0.0000145-in. displacement at bearings.

Its design complies with the requirements set by the Standards Subgroup of the SAE Tooling Subcommittee E-21.

The basic structure of the machine consists of a rigid vertical beam-and-tube frame mounted on a base. Within the frame hangs a

Static unbalance condition causes disk to come to rest always in one position. Dynamic unbalance in cylindrical body forces it to seek new axis of rotation.

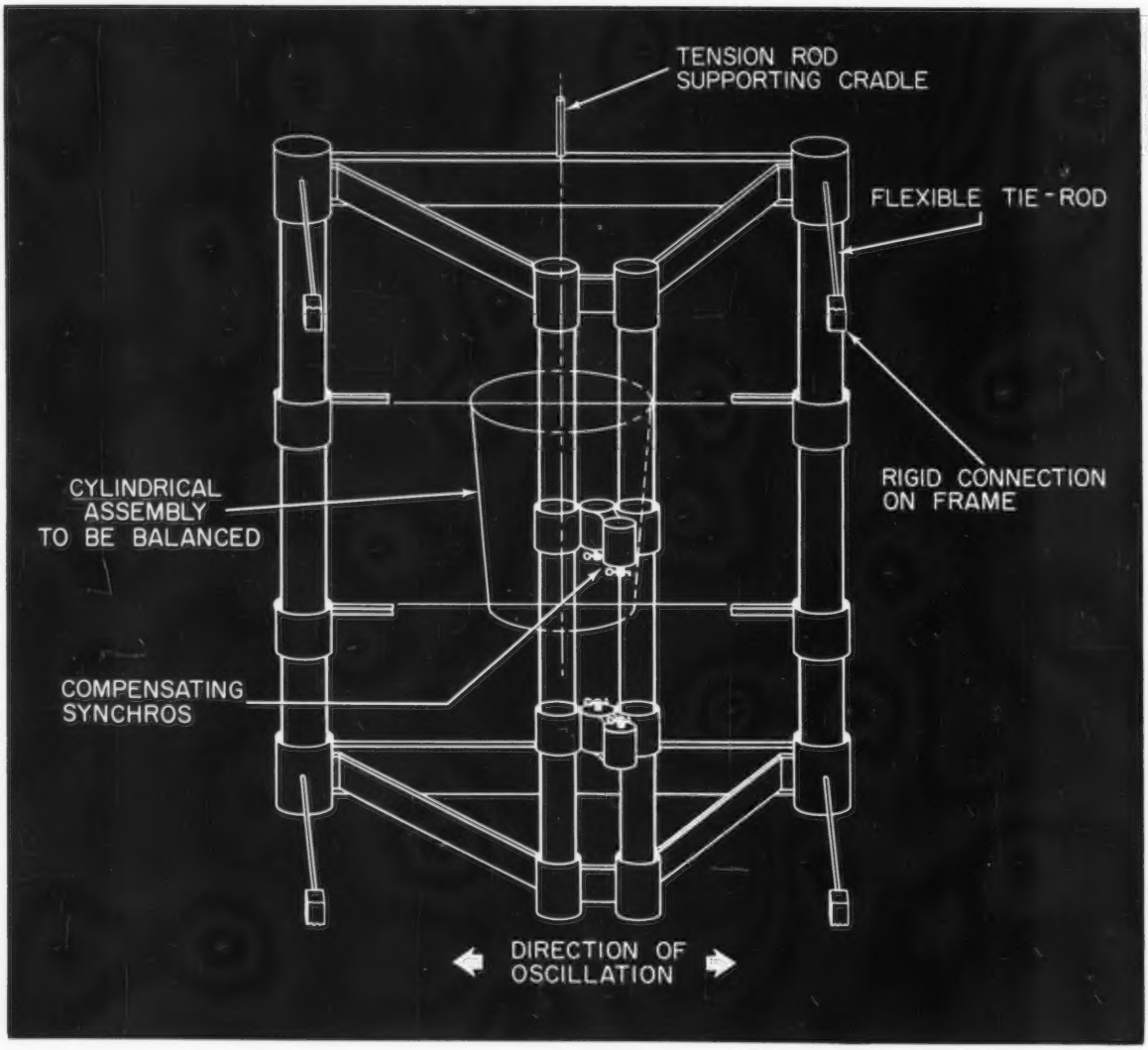


vertical balancing . . . continued

cradle suspended from a single tension-rod like a pendulum. As viewed from the front, the cradle can oscillate only sideways; fore-and-aft motion is restrained by four flexible tie-rods connecting the cradle to the rigid frame. The cradle structure is of four tubular columns joined at either end through tie-brackets. The upper tie-bracket is suspended from the tension rod; the lower tie-bracket takes the thrust loads created during balancing. Two horizontal work-support carriages ride the two front columns of the pendulum cradle. The assembly to be balanced is mounted between the carriages and enclosed in a cylindrical shroud (omitted in illustrations) to stop air-pumping. A belt-driven pulley and drive adapter rotate the assembly at 750 rpm, through the lower tie-bracket; the cradle is provided with locks for use while loading or unloading the work.

Driving power is supplied by a 20-hp motor mounted on frame base, directly behind the cradle. The motor shaft is vertical to the base, and it turns the drive-shaft pulley through a segmented "V" belt. The cradle is provided with electrical compensating devices placed in two pre-selected planes of correction. Each compensating device consists of two synchros, each with a known amount of unbalance mounted on its rotor; removable weights provide the unbalance.

Details of pendulum-cradle assembly with motion-restraining tie-rod system.



The synchros are driven by a generating selsyn whose rotor is operated at shaft speed by a timing belt.

The compensating synchros also have their rotors operating at shaft speed, since they are electrically connected through differential synchros to the generating synchro.

A control console is also provided which is equipped with two separate pairs of differential synchros; one pair for each plane of correction. These synchros are so arranged mechanically and electrically that their rotors can be turned in unison to control the angular position of the compensating weights.

The stators or differential synchros (on console) can be turned so that the vector resultant of the compensator weights will have any value between zero and maximum. The control console thus provides two controls (angle and amount) for each plane of correction. Since the console is operated by the adjustment of calibrated angle and amount dials it is its own memory device.

Electrical pickups mounted on the cradle indicate its vibrations; from these it will be known whether unbalance compensation has been effected. That is whether oscillation of the suspended cradle has been stopped through a controlled amount of induced unbalance. The amount and angle of effective compensation registered on console, determines the location and extent of material to be added or removed from part being balanced. The machine is likewise adaptable to single-plane static correction.

There are no calibration problems in this machine because known compensating weights are used to oppose unbalance. To check operations of compensators it is only necessary to remove the known weights (snap-on type) in the compensators and check for any residual. Since compensator weights can not change, and are at a fixed radius, the machine cannot get out of calibration; this speeds up to balancing operation. Also, the foolproof operational procedures of the machine obviate the need for highly skilled operators.

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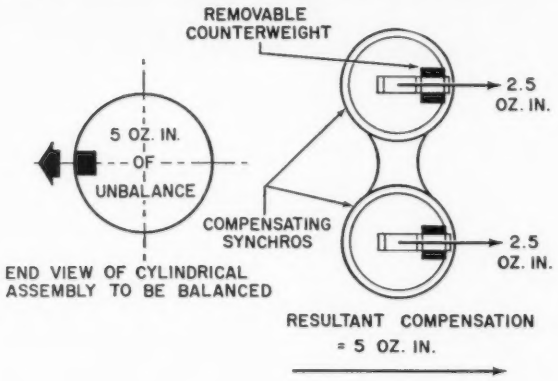
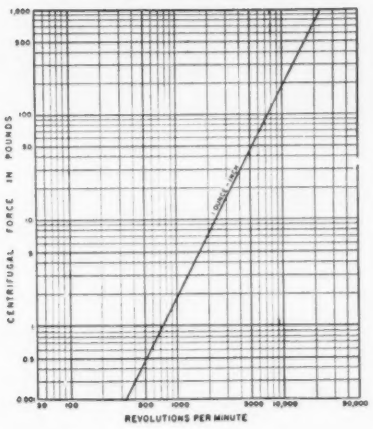
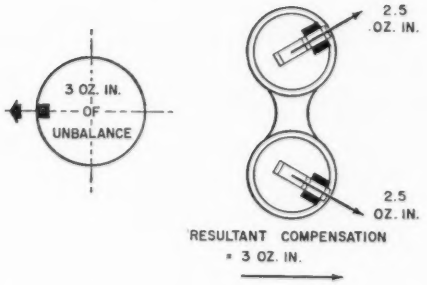
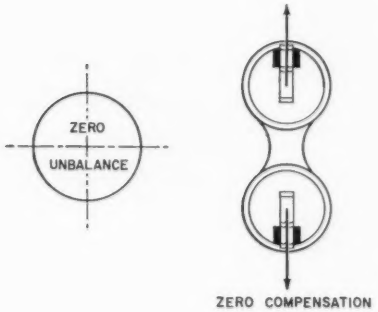
Relative position of synchro counterweights determines the amount of compensation (induced into vibrating cradle) needed to counteract unbalance oscillations.

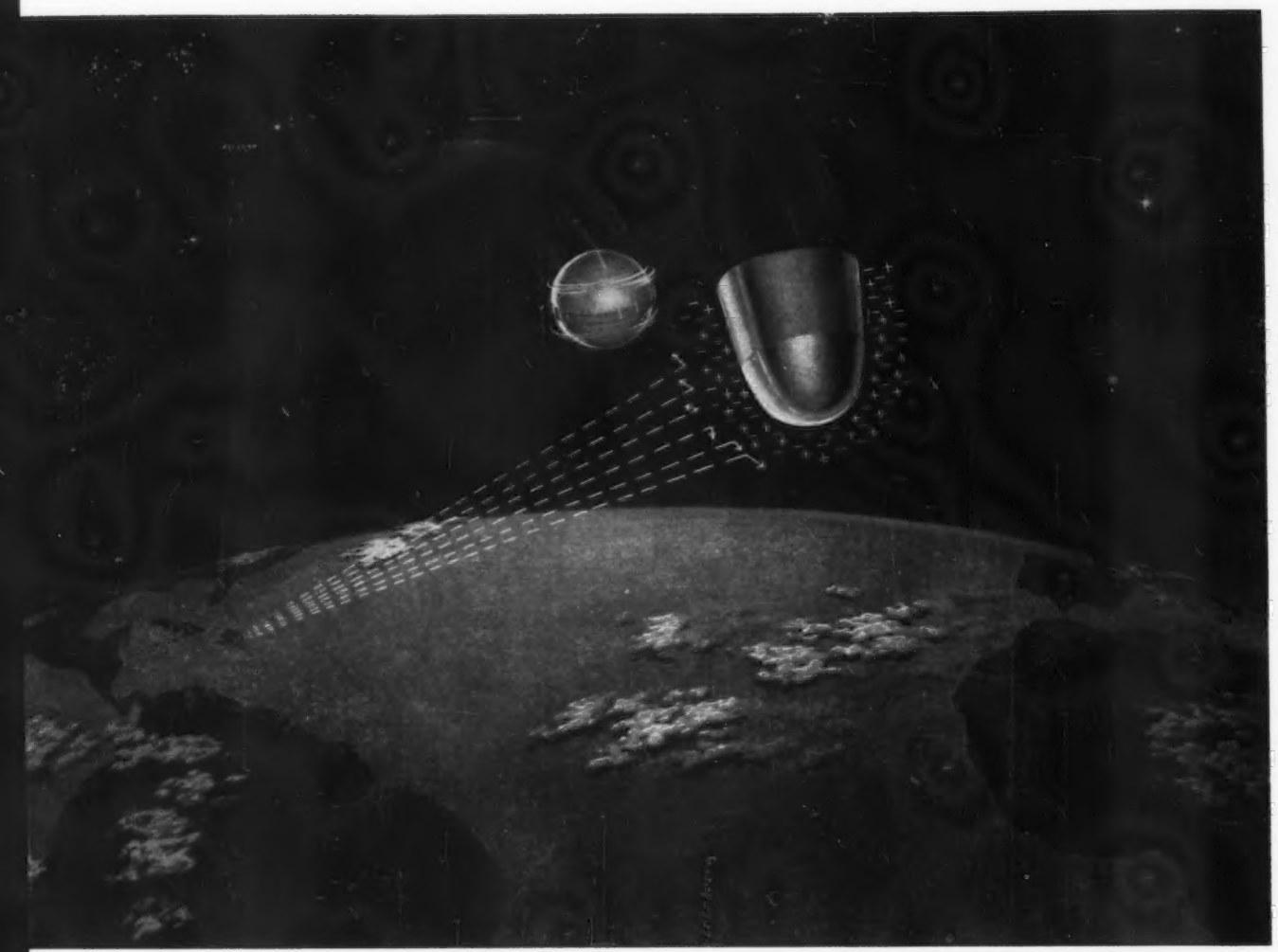


Unbalance builds up rapidly through increasing rpm.









Ionized layer of gases which builds up around nose cone during reentry and confuses telemetry data. Direct reading instruments contained in Datasphere record data on tape. Datasphere weighs about 97 lb, is ejected from nose cone by JATO bottle.

reentry data capsule

limitations of telemetry make direct-reading instruments necessary in collecting reentry data; plastic packaging allows instruments to withstand 45,000 g impact

by John P. Kushnerick

Instrumentation in the data capsule of Thor and Atlas ballistic missiles is capable of withstanding 45,000 g external impact loadings for several micro seconds. This condition is encountered when the instrument package free-falls to Earth's surface on the latter half of the ballistic reentry trajectory. The feat is made possible as a result of close cooperation between the packaging industry and the missile industry, in encapsulating the instruments in energy absorbing urethane foam.

Recovery of data from the reentry phase of a ballistic missile flight has been a perplexing problem because of the limitations of telemetry. During reentry, the tremendous speeds (15,000 mph) create a layer of ionized gases around the reentry body which confuse and often invalidate telemetry data. As a result, direct reading instruments inside the body must be used to collect the data. A coded tape is used to store the information, the tape is later translated to readable data.

The success of this operation presupposes three conditions: (1) that the instrumentation package will survive reentry; (2) that having survived reentry, it will withstand impact forces encountered in freefall to Earth's surface; (3) that having survived impact, it can be located easily for physical recovery.

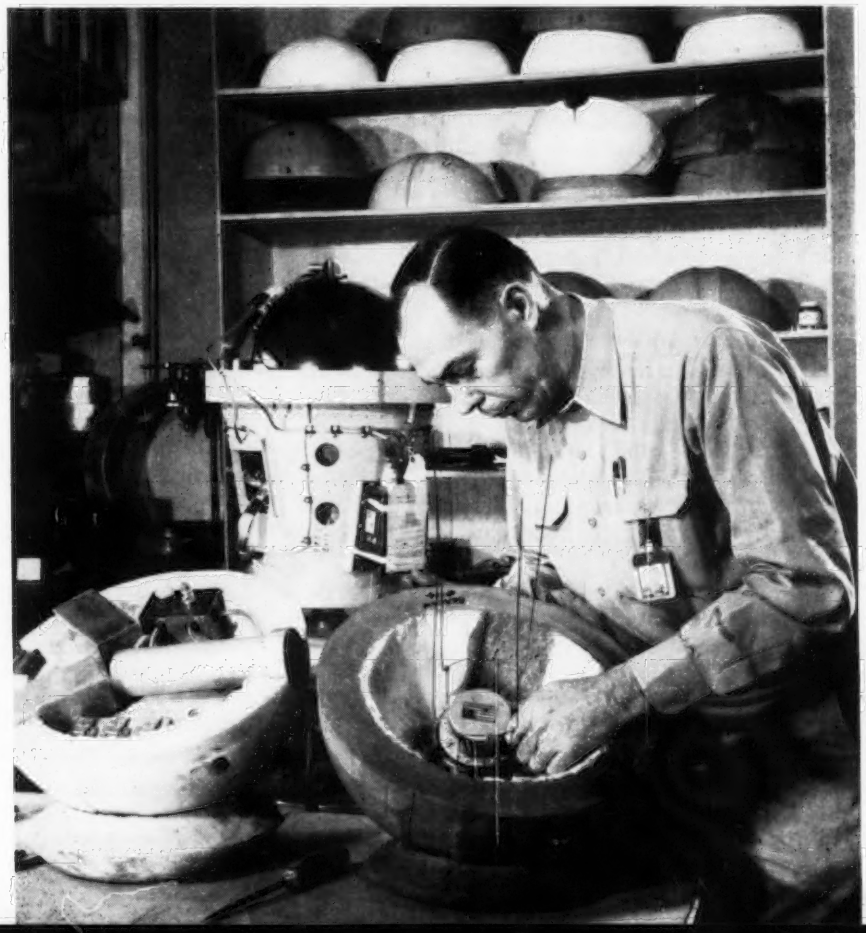
In Air Force's program (Thor and Atlas) the direct reading instrument is an Ampex tape recorder with 30 sec recording time. The recorder and various audio and visual locating devices are encapsulated in an 18-in. polyurethane - foam sphere, protected with a ¾ in. fiber-glass epoxy laminate. The sphere is normally ejected from the nose cone by a JATO bottle at a preprogrammed altitude, after reentry phase has been partially completed. The outer fiber-glass epoxy laminate is in the same family as ablative nose cone material and can itself withstand reentry if it is ejected from the nose cone too early in the ballistic trajectory.

On impact with the ocean, along the South Atlantic missile range, metal clips which hold the outer epoxy shell in place are sheared and the urethane-foam Datasphere floats to the surface. Offset center of gravity causes the sphere to strike the water and float right-side-up.

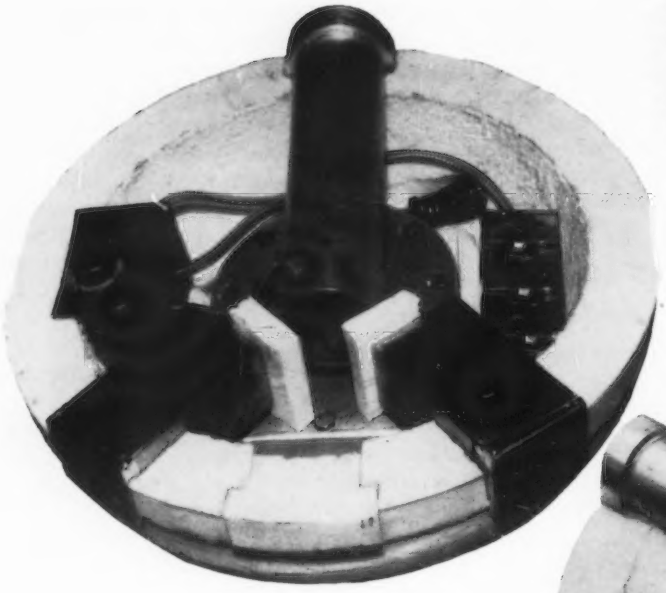
Audio and visual aids incorporated in the Datasphere are then triggered to facilitate recovery. These include two dye markers, a SOFAR (sound fixing and ranging) bomb, and a radio homing beacon.

Manufacturing Detail

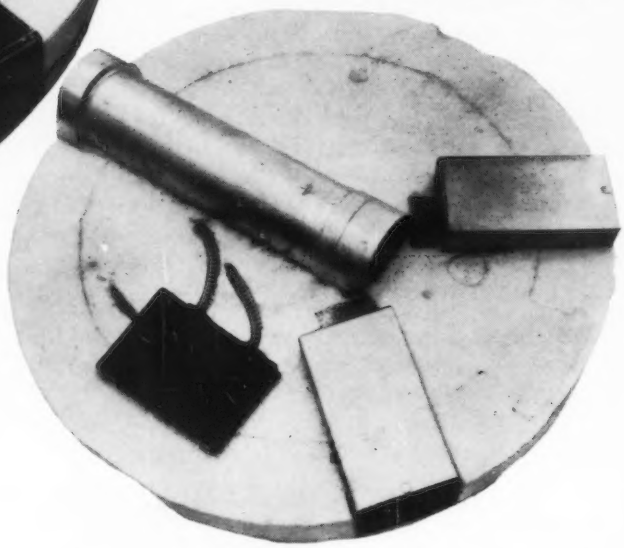
Manufacture of the Datasphere begins with the fabrication of the two urethane foam hemispheres. The resin formulation is a result of cooperative effort between General Electric Co., designer of the Datasphere; Isocyanate Products,



Technician is shown positioning radio beacon in upper urethane-foam shell of Datasphere. Lower shell with instrumentation installed is at left. Completed Datasphere with epoxy-fiberglass shell and clamps in place sets in JATO ejection-housing at rear.



Major portion of Datasphere instrumentation is contained in lower shell. Clockwise from 12 o'clock position are: SOFAR bomb, sea-water switch, two dye markers, dc electrical source. Tape recorder is at center beneath SOFAR bomb.



Instruments are later encapsulated in urethane foam of lesser density than shell. Inner material is 8 to 10 lb/cu ft, outer is 25 lb/cu ft.

reentry data capsule . . .

continued

resin formulators; and Standard Plastics, fabricators of the hemispheres. The formulation is based on Hylene TM (isocyanate) and castor oil adduct, with a suitable catalyst. When cured, the unicellular energy absorbing foam has a density of about 25 lb/cu ft, and possesses the happy combination of flexibility, strength, and limited rebound.

The hemispheres are formed using male and female molds made of cherry wood. Paraffin, or silicon grease, is used as a parting agent. The male portion of the mold is contoured to provide an inner surface that will nest the instruments the shells house. The male portion of the mold is also used to position an aluminum cable and stud that are imbedded in the foam and later used as antenna connections.

Precise quantities of the formulation are poured into the female mold and the male mold is clamped in place. After curing for several hours at elevated temperatures, a hemisphere of 18-in. OD and 2-in. wall thickness is removed. Weight is about 2100 gms.

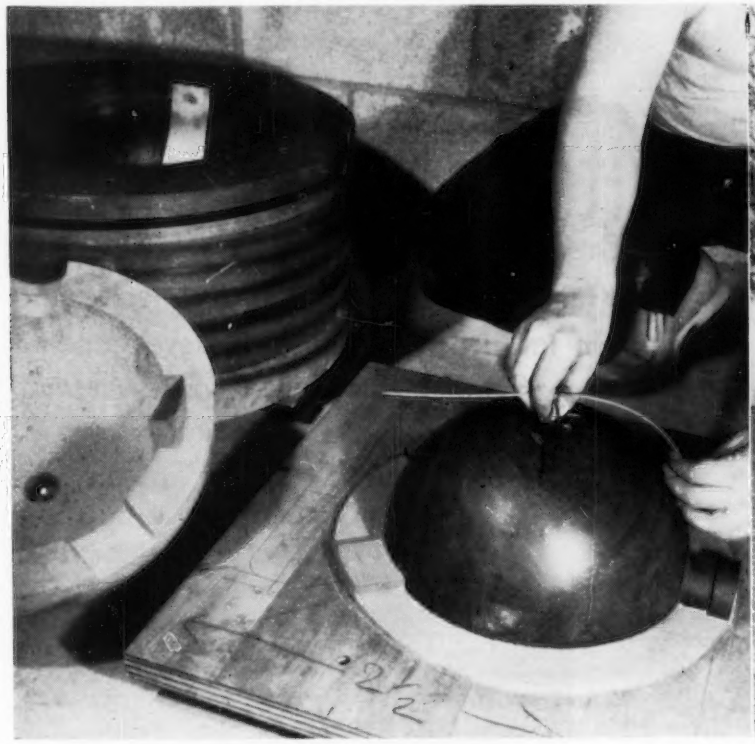
The mating hemisphere is fabricated in the same female mold, however, a different male mold is used because nesting of instrument package requires a specially shaped inner surface for top and bottom hemispheres.

Hemispheres are shipped to General Electric MSVD where the Ampex tape recorder, two dye markers, a radio beacon, a SOFAR bomb, and battery power are positioned in the lower hemisphere. A similar urethane foam, but of lesser density (8 to 10 lb/cu ft), is poured over the nested instruments. Antenna for the radio beacon is placed in the upper hemisphere and similarly encapsulated. When the inner foam is cured the hemispheres are joined, utilizing additional quantities of the 8 to 10 lb/cu ft foam under heat and pressure.

The completed urethane foam sphere is next enclosed in the two epoxy-fiber-glass shells. Seam of the outer shell is in a plane 90 deg to inner seam. Clamps designed to unlatch when the Datasphere impacts with Earth are the only device used to hold the epoxy case in place.

Improvements

Three Dataspheres have been recovered, but not without difficulty. Earliest problem was



Workman is shown positioning antenna lead on male cherrywood mold. Completed hemisphere with antenna attach post is shown at left. Female mold is at left, rear.

Cutaway of 2-in. urethane foam shell shows how antenna wire is imbedded and attached to threaded aluminum stud.

Improvements have been made on Datasphere to incorporate 1 million candle power Strobe light for night recovery. Indentations house lights. One model is shown here with typical fiberglass-epoxy outershell. Shell is similar to ablative nose cone material and can withstand reentry conditions.

that sharks attack the polyurethane sphere. This was handled by including shark repellent in the resin. It was also discovered that night recovery was not simple, even though the pulsing radio beacon brought the search ship within several hundred feet of the bobbing sphere. Luminous scotch tape was used as an interum measure to incorporating luminous dyes in the resin and imbedding strobe lights in the foam. Lastly, lack of identification on spheres resulted in at least one being held for several months by natives on a South Atlantic Island after it washed ashore. Suitable identification plate will be incorporated in future spheres.

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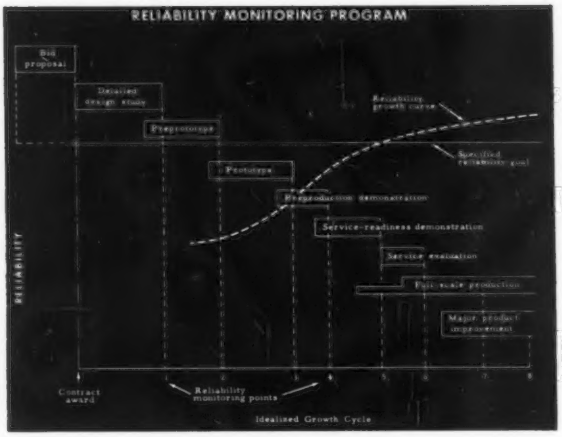
monitoring reliability

failures point out value of check-point program for use in the design, development, and production of guided missile weapons systems.



This article outlines a proposed reliability monitoring program for use with guided-missile weapons systems projects. The program was developed by the Ad Hoc Committee for Guided Missile Reliability, which was organized under the Office of the Assistant Secretary of Defense (Research and Engineering) and is now sponsored by the Office of the Director of Guided Missiles.

A significant number of guided-missile weapons systems have failed to achieve the required reliability in the time scheduled and with the funds allotted. Military planning has been upset; funds that might have been usefully applied to more productive projects have been "wasted," and the operational use of the missile system has been postponed.

To help assure reliability, the military services and industry need an adequate, uniform monitoring program and management procedure that can be effectively used for all types of guided-missile projects.

The program proposed is based on the premise that reliability can be quantitatively specified, estimated, assessed or measured at predesignated steps of weapon system's life cycle. Further, that it can be controlled throughout the phases of design, development, production and major product improvement.

Scope

The plan consists of a number of fixed points at which reliability is reviewed. This will supplement, not replace, the contractor's regular reliability monitoring activities. Continuous monitoring by the contractor provides basic data for use by the contracting agency.

The first estimates of reliability, made in a feasibility study or in the project's prehardware phase, will be derived mainly by using prediction techniques.

Monitoring Points

Points at which reliability is predicted, measured and reviewed are at the end of each of the following phases:

- Detailed design study
- Preprototype
- Prototype
- Preproduction demonstration
- Demonstration of service readiness
- Service evaluation
- Full-scale production
- Demonstration of major product improvement

Detailed Design Study

The military should provide the contractor an analysis of the intended uses of the weapon system, which includes numerical reliability requirements. Concepts of operational maintenance and over-all logistics must also be furnished.

The report at this monitoring point should describe how the specified reliability is to be achieved. It should include the following minimum information: design maturity and experience background on major portions of the proposed system; wherever possible, a quantitative analysis of the reliability of the weapon system. Basis used for arriving at the reliability estimates should be described.

The administration of the program during design, development and production should be described in detail with respect to (a) optimizing operational reliability, (b) a survey of reliability personnel and the organization, facilities and procedures to be used, (c) the acquisition and analysis of failure data and (d) the design of special requirements for production quality control. It should also outline the plan for testing components and systems. The basis for determining inspection and test criteria, including sample size and test conditions, should be presented. Sequential sampling and analysis procedures should be used wherever applicable, and confidence levels should be established.

Preprototype

This point may be identified as "95 per cent of engineering released."

A review should be made of the division of system and subsystem reliability requirements, i.e., an allocation of reliability allowances for portions of the system developed in detailed design. System-reliability estimates must be reconsidered using performance data from other sources.

Reliability requirements should be established for:

(1) Post acceptance handling and testing at the contractor's facility.
(2) Transportation and testing at receiving, storage, and launching site.
(3) Readiness checkout phase.
(4) Decision to fire (in ready condition) up to the missile's commitment to flight.
(5) In-flight phase.

The contractor should review the effect on reliability of operation, maintenance, human-factors and over-all logistic concepts to determine and define the foregoing phases.

ENVIRONMENTAL TEST CRITERIA are likely to differ for various parts of the system, e.g., ground-based equipment, equipment located in different areas of the missile. Accordingly the most critical subsystems or parts should be so tested.

DESIGN CHANGES should be formally reviewed by the contractor. Any changes submitted to the contracting agency for approval should include estimates of their effect on system reliability and logistic factors, as well as project cost and schedule.

DOCUMENTATION of necessary design changes and tests of reliability should be made in the reports. These should also include a complete description of the data and test conditions.

SPECIFICATIONS, both military and contractor, should be reviewed in the light of established requirements. Specification changes should be submitted to the contracting agency for review and approval in accordance with established policy of the procuring agency.

Prototype

The first complete sets of missile hardware are available at this point and can be assembled into the general physical configuration. Laboratory testing will have been conducted to demonstrate the compatibility of weapon system and subsystems. Special test vehicle flights to obtain data for design improvement are performed in this phase.

ANALYSIS AND MANAGEMENT through qualification testing, of electronic, electrical, electrochemical and mechanical component parts and subsystems should be under way at this stage. This should include tests to determine compliance specifications. These tests, combined with reliability studies, should provide information on performance limits, operating time to failure, and mode of failure.

Ground testing should be conducted to assess reliability and measure operating time to failure. The results of these tests should serve to verify or modify the requirements determined as the result of the analyses.

DOCUMENTATION, in progress report form, through the missile prototype phase should contain the engineering (R&D) data obtained from qualification testing and the results of tests to determine reliability. It should also include a comparison of present reliability levels of the weapon system and subsystems with the objectives established in the design proposal phase and a predicted-reliability growth curve justified by experience and facts.

A positive program to improve equipment that fails to meet the reliability requirement (established in the design proposal) shall be included in the progress report.

continued on next page

monitoring . . . continued

Preproduction Demonstration

Now the design of the weapon system is essentially complete and is ready for production. A demonstration of the reliability achieved during this stage provides one of the bases for assessing the system's readiness for full-scale production.

The contractor should perform flight tests and ground tests. Component-parts qualification tests, initiated earlier in the program, should be completed in this stage.

A report of the demonstration of performance and reliability of the guided-missile weapon system and subsystem should be prepared. It should include a complete summary of flight and ground-test findings and the results of analyses of deficiencies uncovered during the tests. In addition the performance and reliability achieved should be compared with that specified in the contract. The program for the correction of deficiencies should also be presented and discussed in the report.

Demonstration of Service Readiness

At this stage the contractor is required to show that the weapon system built under the limited- or pilot-production program has reached the reliability objectives—that the system can be produced in quantity without significant loss in performance or reliability.

An adequate and uniform production sample for service-readiness tests should be available. The design and development of the weapon system should be completed, although improvements may be contemplated.

Tests will be under the direction of the contractor, who will demonstrate the operation of the weapon-system equipment by means of laboratory, captive-firing, flight and field tests. The contractor will show that the weapon system is sufficiently mature for release to the military for independent evaluation. Military personnel should be trained by the contractor. This use of military people will provide and evaluate training programs and will indicate how well they can operate and maintain the equipment.

An analysis should be made of the potential operational reliability of the weapon system, using techniques that will permit a comparison of the ground and flight-test measurement.

Documentation, made at this monitoring point, should include descriptions of the analysis techniques and test procedure used. The predicted-reliability growth curve and how it was derived should be included.

A positive program should be presented in the report, with details of the improvements to be made to meet the reliability objectives.

All applicable military specifications should be reviewed to determine whether the results of the foregoing sections indicate that some specification change is needed.

Service Evaluation

During this phase, the military uses its own personnel to perform weapon-system evaluation.

TESTS should involve flight or laboratory evaluation. Throughout this stage, a major item is the measurement of system reliability under simulated combat operations.

Full-Scale Production

The primary aim at this stage is to ensure that the level of reliability designed into the system is maintained during production. Results shall be continuously monitored using acceptable quality-control techniques. Guides for the contractural establishment of quality-control programs are available in MIL-Q-5923C and MIL-G-11461 (ORD). Both factory and field results shall be analyzed so as to detect or warn of reliability problems.

Laboratory environmental tests, flight tests and quality-control tests shall be performed on production samples as necessary to maintain the required level of reliability.

The contractor should be responsible for laboratory and quality-control tests. The contracting agency will be responsible for government surveillance of all laboratory, quality-control and flight tests for purposes of monitoring production. The contract should clearly indicate whether the contracting agency is to be responsible for the production-surveillance flight tests.

Demonstration of Major Product Improvement

At this point, the performance, reliability and over-all value of product improvements are demonstrated.

The contractor should demonstrate the value of major changes in the weapon system by design analysis and by laboratory and system-operation tests.

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how to cast curved passageways

vanishing cores eliminate complicated machining and external plumbing

by G. Sandenburgh, manager of engineering, Hills-McCanna Co.

Whether they are called "cored passages" or "tubeless passageways," these influence directly the quality and cost of light-alloy sand-castings. Small diameters or large unsupported spans of casting passageways, by the use of conventional sand cores, presents a problem. Sizes and shapes of sand cores are limited by the relatively low mechanical properties of oil-bonded, synthetic resin-bonded or chemically bonded sand.

To circumvent these difficulties the Hills-McCanna Co., of Chicago, has developed the "McCannacore" (Patented) process. This process makes use of glass-like tubes which are bent and/or joined to form the desired passageway configurations. The forming and joining fixtures for these tubes (cores) are made to the same shrinkage allowance used for the pattern. The core material is removed after the casting operation by chemical dissolution in a hydrofluoric acid bath.

It is known that this acid has no effect on magnesium-base alloys. Contrary to general opinion, aluminum-alloy castings have also been treated with hydrofluoric acid without detriment; no intercrystalline corrosion has been detected through microscopic examination at 100 magnifications. McCannacores are given an external coating of a distinct yellow color. This coating was chosen for its optimum combination of high radiographic density and inertness to molten magnesium. The high density to X-Rays results in a light line around cored passageways seen on radiographs of castings. This light line appears on the radiographs until all of the core material has been dissolved. This insures a thorough removal of all core material from the finished casting.

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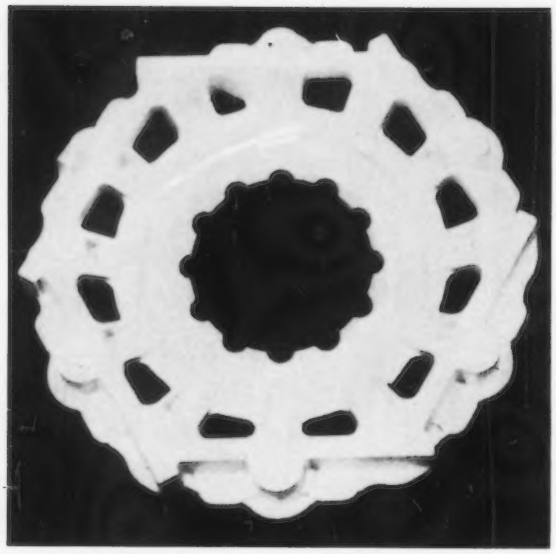


Fig. 1. Aircraft brake casting with drilled passageway for hydraulic fluid.

As compared with drilling, the use of tubeless passageways offers the following advantages.

Designability: not being restricted to straight centerline configurations, can be located wherever needed. The designer is also spared the difficult task of arriving at intersecting drill patterns.

Reliability: elimination of unnecessary exit and entrance parts obviates use of pipe plugs and attendant leakage and boss-cracking hazards.

Improved functioning: filleted junctions, smooth bends and transitions of cross-section decrease pressure drop and turbulence. Elimination of drilling also prevents internal burrs and chip traps as potential sources of contamination.

Fig. 2. Aircraft brake design incorporating cored passages.

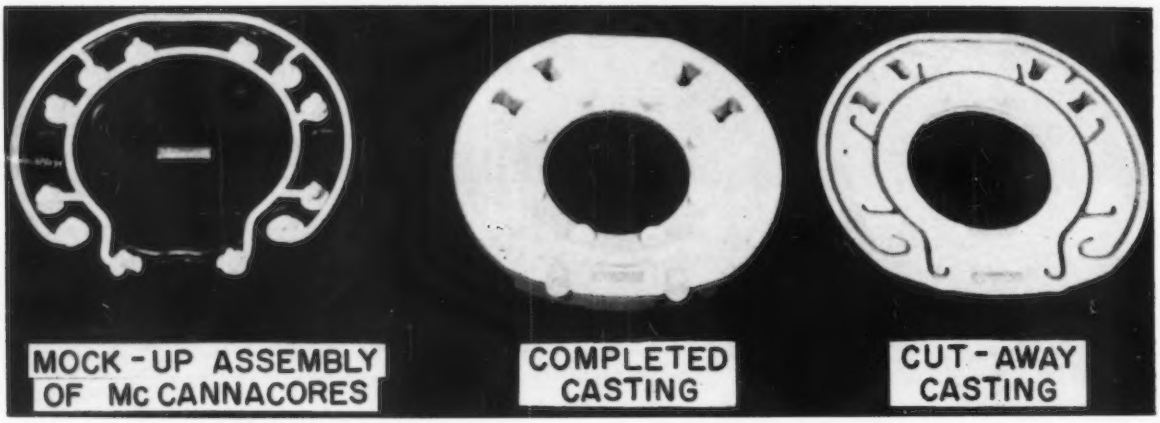


Fig. 3. Core assembly used for lubrication system passageway in helicopter transmission housing.

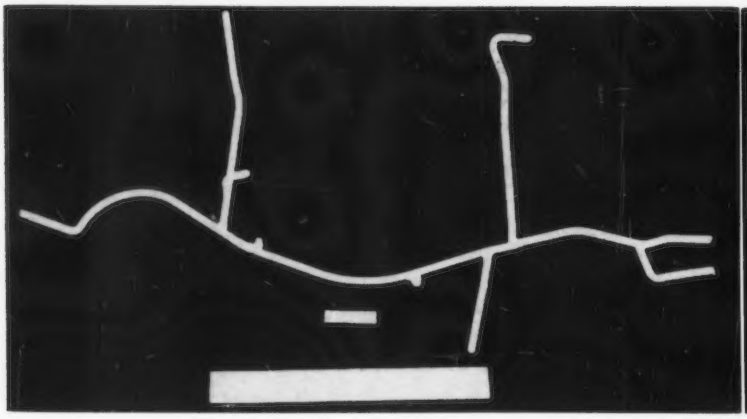
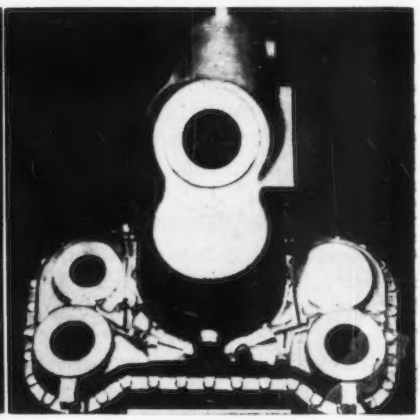


Fig. 4. Casting of helicopter transmission housing.



Economy: the unit cost of castings with tubeless passages will obviously be higher than the same part without passages. However, if the long-run machining-labor and scrap costs of the conventional drilling method are considered, tubeless passageways would be cheaper.

Typical Advantageous Applications

The examples shown in the accompanying figures are discussed to illustrate typical applications for the McCannacore process.

Fig. 1 shows a conventional aircraft brake casting. The brake cylinders are machined into the casting from the side opposite to one shown. Hydraulic fluid is transmitted to the cylinders through passageway formed by six intersecting drilled passages. In this design about 1/5 lb. magnesium alloy would have been saved by using a circular tubeless passageway; fluid flow characteristics would have also been improved. Re-entrant corners (extensions of drilled passages beyond intersection points) would have been avoided; these corners are air traps hence require power bleeding.

Fig. 2 shows a more recent aircraft brake design incorporating tubeless passages. This design includes two completely-separate passageway systems; one is for hydraulic fluid and the other for compressed air. Fig. 3 and 4 illustrate application of tubeless passageways to the lubrication system for a helicopter transmission housing. Here, 73 in. of ¼-in. diam core material is used in one integral assembly; it is rigid enough to be held horizontally from one end without breaking or warping. This core was advantageously embedded into the wall of the casting shown in Fig. 4; drilling of an equivalent passageway would have been difficult and costly. The dimensional accuracy of the eight parts involved was within less than 1/64 in. The passageway was checked by exposing it and calipering the wall thickness. A maximum shift of 0.019 in. was found; this was well within an allowed shift tolerance of 1/32 in. Fig. 5 shows a casting of the

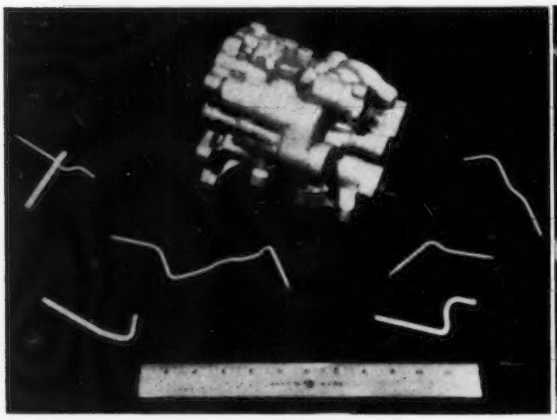


Fig. 5. Casting and cores for a jet engine fuel control unit.

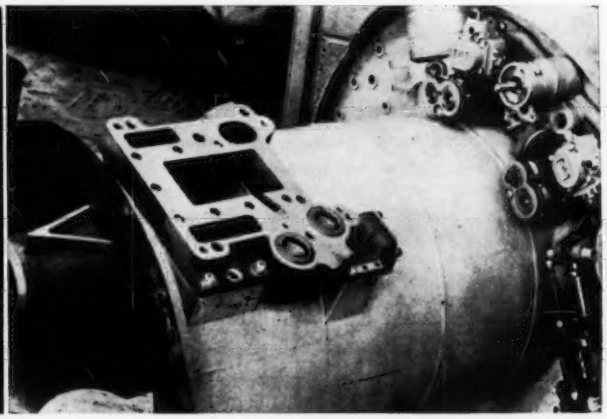


Fig. 7. Missile hydraulic-system casting incorporating integrated plumbing.

Fig. 6. Complex coring in an auxiliary power unit housing for a missile application.

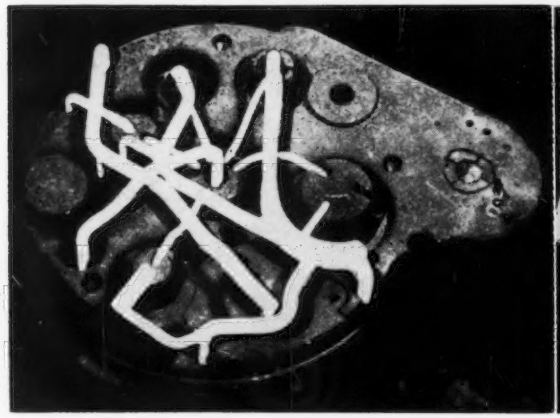
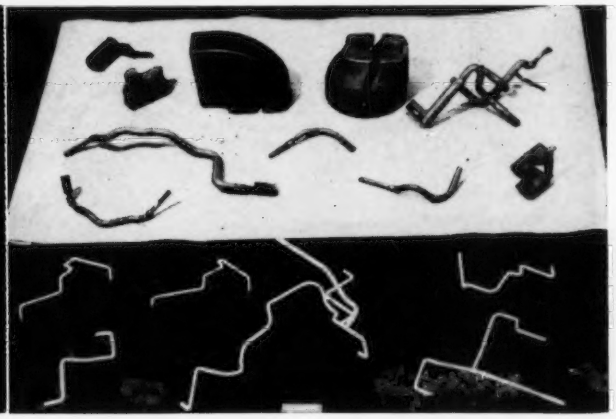


Fig. 8. McCannacore assemblies and sand cores used for casting shown in Fig. 7.



main housing for a jet engine fuel control. There are six ⅛-in. diam cored, sensing passageways in this part. One of these runs through the entire body of the part wending its way in an irregular course. In addition to the six McCannacores there are 27 sand cores required in the mold assembly for this unit.

The extreme complexity of passageways that can be obtained is illustrated in Fig. 6. This is an auxiliary power-unit housing for a missile application; both the lubrication system and the fluid transmission system have been cored. This design would require extensive modification if machined passageways were to be used.

Tubeless passageways are also being used in the production of castings for integrating plumbing. An application of this type was used for the integration of several hydraulic lines within a missile, with the following results. A number of lines were eliminated, resulting in simplified design; the hydraulic system could now be tested separately without tying up the entire missile; the leakage hazard was minimized; and through the resulting reduction of parts assembly time was reduced. Fig. 7 shows this casting during an intermediate stage of assembly into the missile. Fig. 8 reveals the six McCannacore assemblies, and the 11 sand core and sand core assemblies used for this casting. Fig. 9 shows a strut-lightener sand core for a jet engine front-frame casting shown in next figure. Two tube inserts are rammed-up inside this sand core; upon casting, the tubes are intimately surrounded by metal only in areas where the tubes emerge from the sand core. In this application the tubes are suspended within the strut-lightener passage visible in Fig. 10; the tubes are seen disappearing into the strut cavity formed by the sand core shown in Fig. 9. One tube can also be seen (Fig. 10) protruding from the hub flange of the casting. Suspension of cast-in tube inserts, within a casting cavity, with an air space surrounding the tubes may provide insulation against heat transfer. Also, where needed, cooling or heating air could be circulated around tubes to achieve desired effects.

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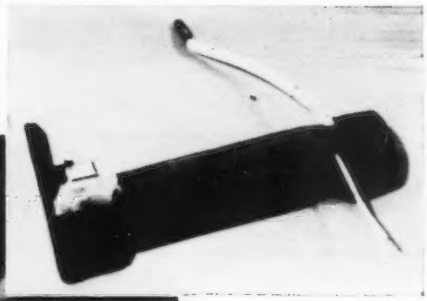
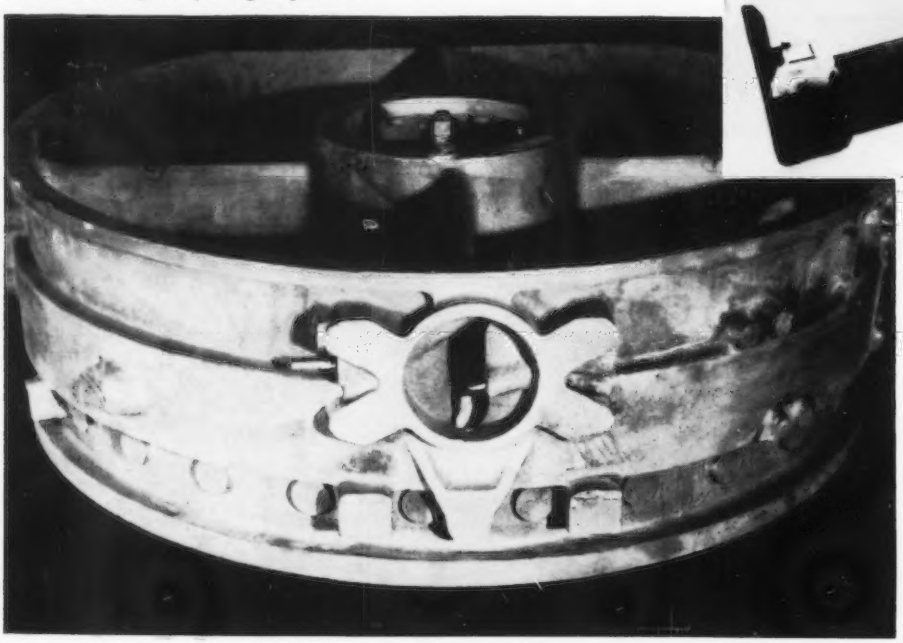


Fig. 9. Strut-lightener sand core for the jet engine front-frame casting shown in Fig. 10.

Fig. 10. Jet engine front-frame casting incorporating four hollow struts. In foreground, strut cavity can be seen leaving the passageway tubes.



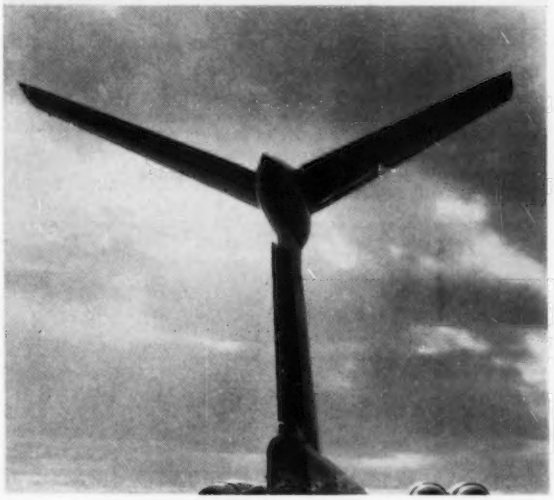
SeaMaster... design concepts

all control surfaces power actuated, electrical motors play supplemental role; aerodynamic design gives performance potential equal to land-based aircraft

by John P. Kushnerick

The SeaMaster program first got underway six years ago. Now flying at Martin's Strawberry Point facility are six revamped Y-models, but it will not be until 1960, when the Navy's East Coast seadrome is ready, that SeaMaster will enter squadron duty. This stretch-out is not usual in the development life of an aircraft, but SeaMaster is no usual aircraft.

Symbolizing a new operational concept in Naval Aviation, SeaMaster is the world's first multijet seaplane; and is the first seaplane to have an aerodynamic design which gives performance potential comparable in all respects to equivalent land-based aircraft. The advent of the jet engine and the departure of the need to keep propellers high out of the water has resulted in reduced frontal area and correspondingly reduced drag. Wing cathedral (negative dihedral) gives improved dynamic lateral stability, and enables wing floats to be mounted on the wing tips, further reducing drag normally induced by float support structures. Recent developments in hydrodynamic design, which include long afterbody hull, low chine bow, and greatly reduced step depth all combine to give a low compact profile with a drag coefficient competitive to land-based aircraft.



• T-TAILS—TREND AT MARTIN

The tail surface is not a piece of adornment nor is it a relic of the past. It has very definite aerodynamic functions necessary to controlled flight. It is possible to transfer some or all of these functions to other components as in the tailless aircraft, however, the wing, which invariably takes on these duties, rarely escapes without impairing its own performance.

SeaMaster incorporates the T-tail, a Martin trademark since the introduction of the XB-51. The T-tail is not a panacea, but it does have some attractive features. It effectively raises the tail above the heavy spray experienced by seaplanes. The horizontal tail surface on top of the swept-back fin also acts as a longer lever-arm than one mounted directly on the fuselage. The top-mounted horizontal-tail surface also acts as an end shield for forces that build up in the fin. Instead of allowing fin forces to suddenly drop off to zero, they are spread over the horizontal surface. This produces side forces that might be considered a disadvantage; however, the use of dihedral can turn these forces to an advantage by increasing yaw stability.

Pitch-Control System, A Major Problem

The pitch-control system has been modified, since it was established early in the program (1956) that much of the trouble was caused by the elevator-stabilizer design, the so-called "flying tail." The "tail" like all primary-control systems on SeaMaster is power-actuated by hydraulics; electrical motors perform supplemental functions. Since there is no feedback of natural aerodynamic forces, through the pilot's control column in a power control system, this is done artificially. Electromechanical actuators regulate these feel-forces in the yaw and roll-control systems, as well as in the pitch-control system. Bobweights are

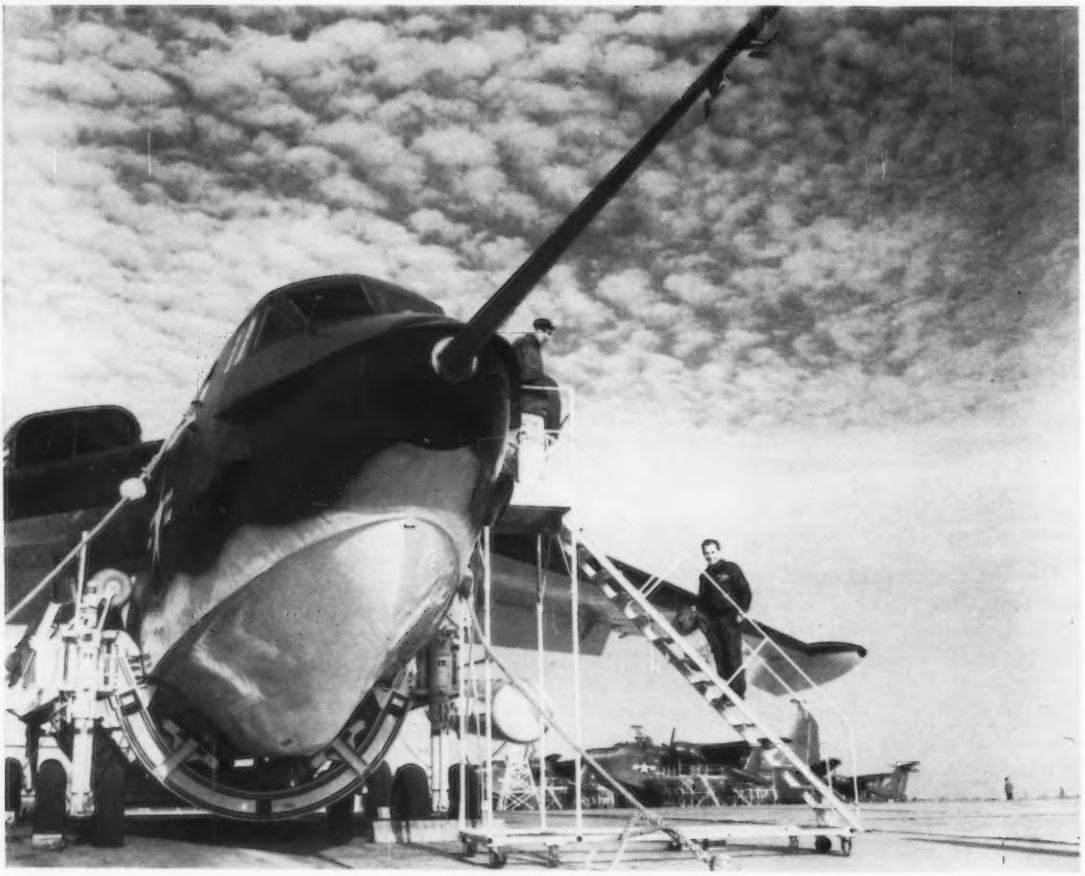
SeaMaster . . .

continued

included in the artificial feel to increase stick forces in proportion to g's exerted. The importance of this feel-system was demonstrated in a flight-simulator, where pilot initiated maneuvers or artificially-induced gusts resulted in an uncontrollable oscillatory divergence in pitch when the pilot did not have the benefit of artificial feel. The divergence was aggravated by the pilot since a human has "imperfect servo capabilities" and has excessive phase-lags in reaction-time.

The tail in present configuration is still a stabilizer-elevator combination. The elevator, how-

SeaMaster symbolizes a new concept in Naval Aviation. Shown here in new beaching gear (AMM, Nov. '58), craft is first multijet seaplane, and first seaplane with aerodynamic design that gives performance potential of land-based craft.



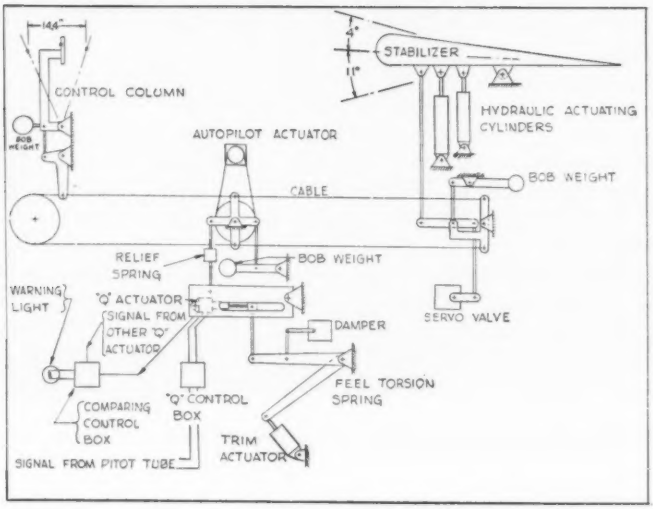


Fig. 1. Schematic shows basic elements of the longitudinal control system.

ever, can be "locked" or it can be "slaved." Its sole function in slaved mode is to provide additional control in landing and takeoff. During high-speed maneuvers and cruise, the elevator is normally locked and the horizontal tail functions as a singular slab. This precludes elevator flutter, and reduces in-flight vibrations.

Operation of Flying Tail

In the slaved position, the elevators are actuated by the stabilizer through a system of pushrods and bell cranks (Fig. 1). When the leading edge of the stabilizer is in the full-up position, the elevators are faired with the stabilizer. When the stabilizer leading edge is in full down position, the elevators are at max throw of 30-deg up from stabilizer chord.

The change in mode of operation from "locked" to "slaved" is performed by a 400-cycle electric actuator. Complete transition requires from 15 to 25 sec depending on loading. Very little trim-change occurs during the transition. Operation of the elevator lock-actuator system is as follows: The electrical actuator (Fig. 2) is energized through a relay and limit switch located in the wing flap so that the elevator is automatically slaved as flaps are extended. Since flaps are not used in the initial part of the takeoff run, there is also an override switch to allow slaving of the elevator while flaps are up. Flap handle must be in the neutral position to accomplish this mode. As the lever is moved to the up position after take off, the actuator automatically locks the elevator to the stabilizer.

Since knowledge of the elevator lock actuator position is considered critical for safe landings and take offs, a dual indicating system is used to warn the pilot of elevator status.

One is a simple light powered by the 28-v dc essential bus and activated by a switch on the mechanical locking-linkage. When the wing flaps are up, and elevators are mechanically locked, the light is out. The second indicator system is powered off the copilot's bus and uses a "locked," "slaved," barber-pole type of indicator. Locked indication is obtained from the actuator which is in series with the linkage switch to the indicator.

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Fig. 2. Drawing (trimetric) shows layout of elevator and stabilizer controls in the tail fin.

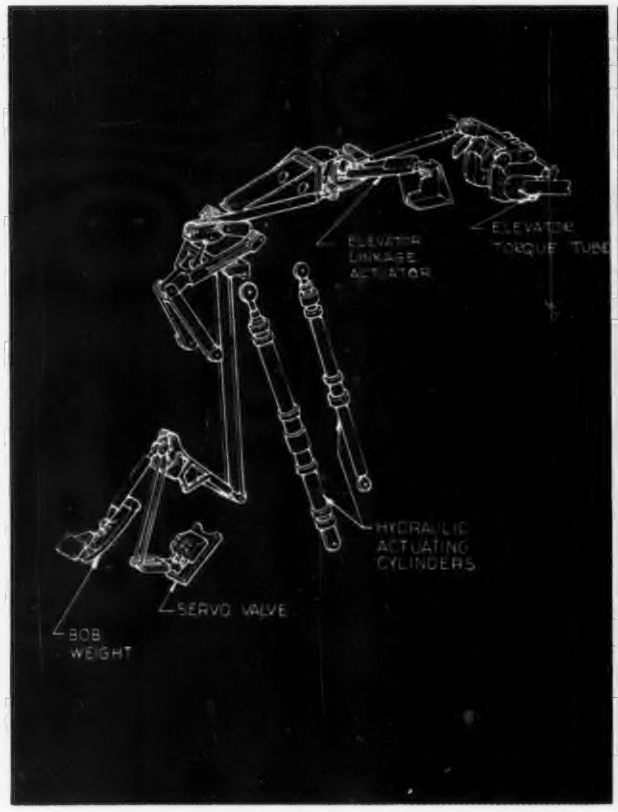
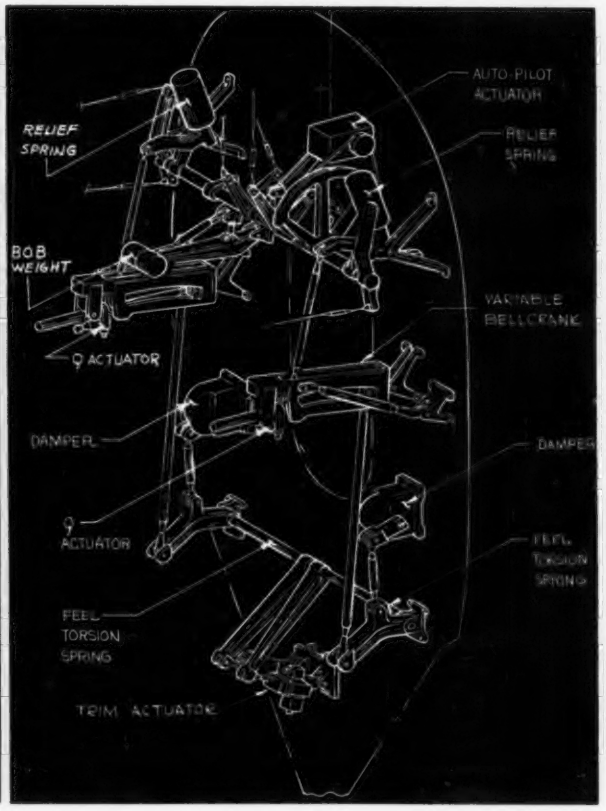
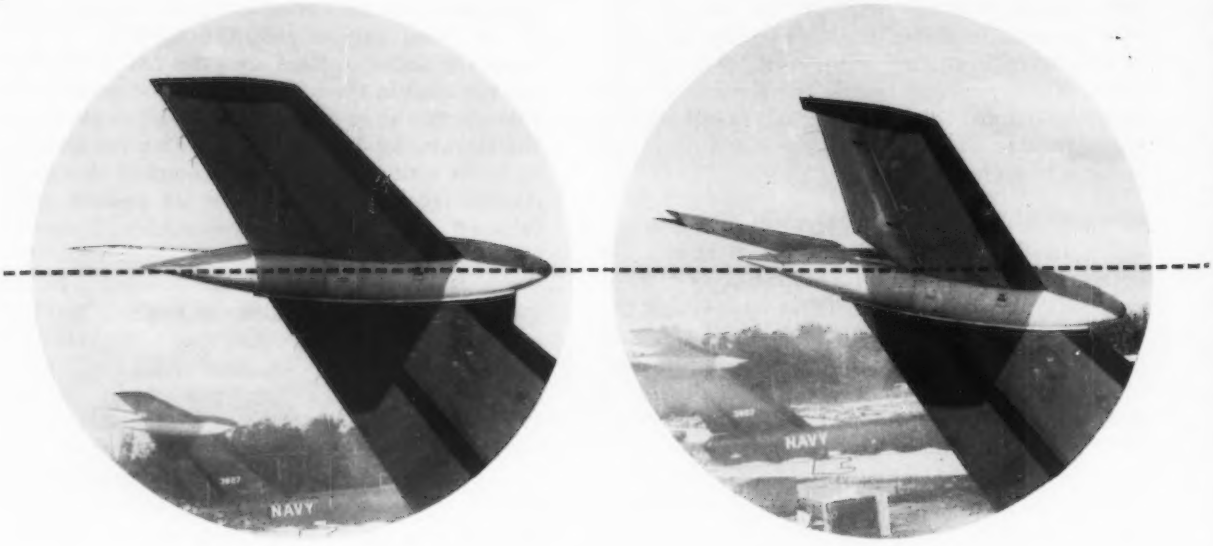


Fig. 3. Elements of the "feel" system in the longitudinal controls are shown in this trimetric.





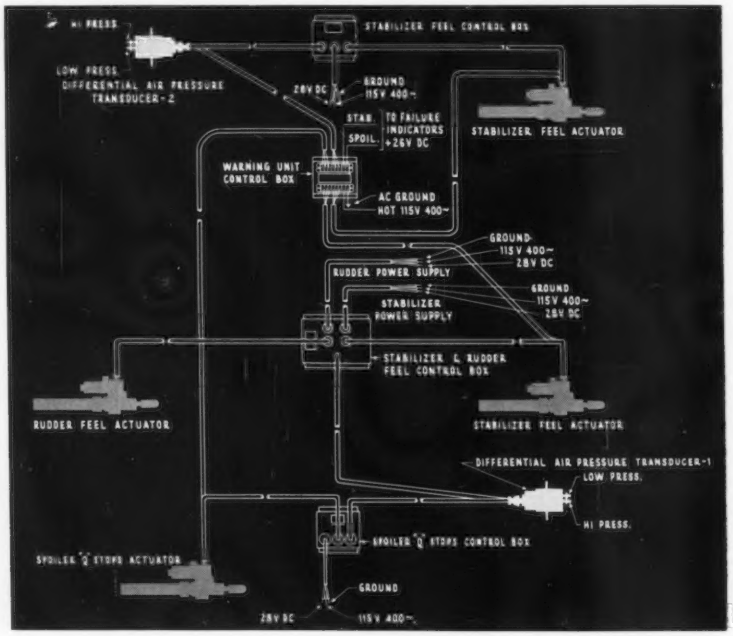
NORMAL FULL-DOWN

SeaMaster . . . continued

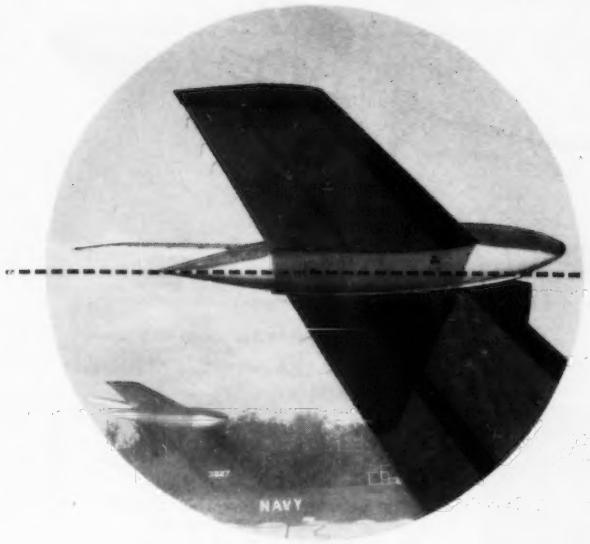
Artificial Feel

The importance of the artificial-feel system was mentioned previously, drawing from pilot limitations encountered in flight-simulator studies. Results of SeaMaster prototype accident investigations clearly pointed out the necessity of designing this system with the same safety-of-flight and failure philosophies as the power control system itself. In addition, the need for flight test vigilance in telemetry was made obvious since the feel system does not give any indication of control surface hinge moments and critical conditions can build up without the pilot's knowledge. This was made apparent in the second prototype incident where load factors of 9.5g were built up in the tail.

The artificial-feel system provides stick forces proportional to stabilizer deflection ($\triangle$) and airplane dynamic pressure (q). The dynamic pressure is picked up from the pitot static-sys-



Schematic of actuator system responsive to "q" (dynamic pressure).



FULL-UP

Stabilizer-elevator combination the so-called "flying tail," has caused major problems in SeaMaster's development. Elevator can be "locked" or slaved." In locked mode tail moves as a single slab. In slaved mode, elevator assumes 30-deg up position when stabilizer is full-down; follows stabilizer in upward deflection.

tems by a pressure transducer which transmits a proportional signal to a control box. The feel system uses a solid shaft as a torsion spring, the spring deflection is proportional to the stabilizer deflection.

As shown by Fig. 3 feel forces are provided by duplicate systems, each furnishing ½ the control force. Each of the dual control column cables is connected through a relief spring, so that in the event of a dynamic-pressure actuator failure the system can thus still be operated. The two pitch-feel systems receive indexing information from different independent sources; one from the pilot's pitot-static system and the other from the co-pilot's pitot-static system.

Each dynamic-pressure actuator is operated independently. However, a comparison feedback circuit is incorporated which compares the stroke of each actuator and lights a warning light when the out-of-band tolerance is exceeded.

The null position of the torsion springs can be adjusted to provide trimmed level flight by electric actuators. Maximum reliability is achieved by the use of two identical actuators mechanically connected in parallel, and of sufficient strength so that either actuator can assume the load in event of breakage of the other. By the use of permanent magnet motors and acme screws on these actuators, a fault from a plus source will not cause a runaway actuator. The actuators are wired in parallel and require switching to simultaneously close the circuit to both the power source and ground. The stabilizer-trim actuators have a speed-rating of 0.039 in/sec ± 25 per cent at 175 lb and ± 10 per cent at no-load.

Other Controls

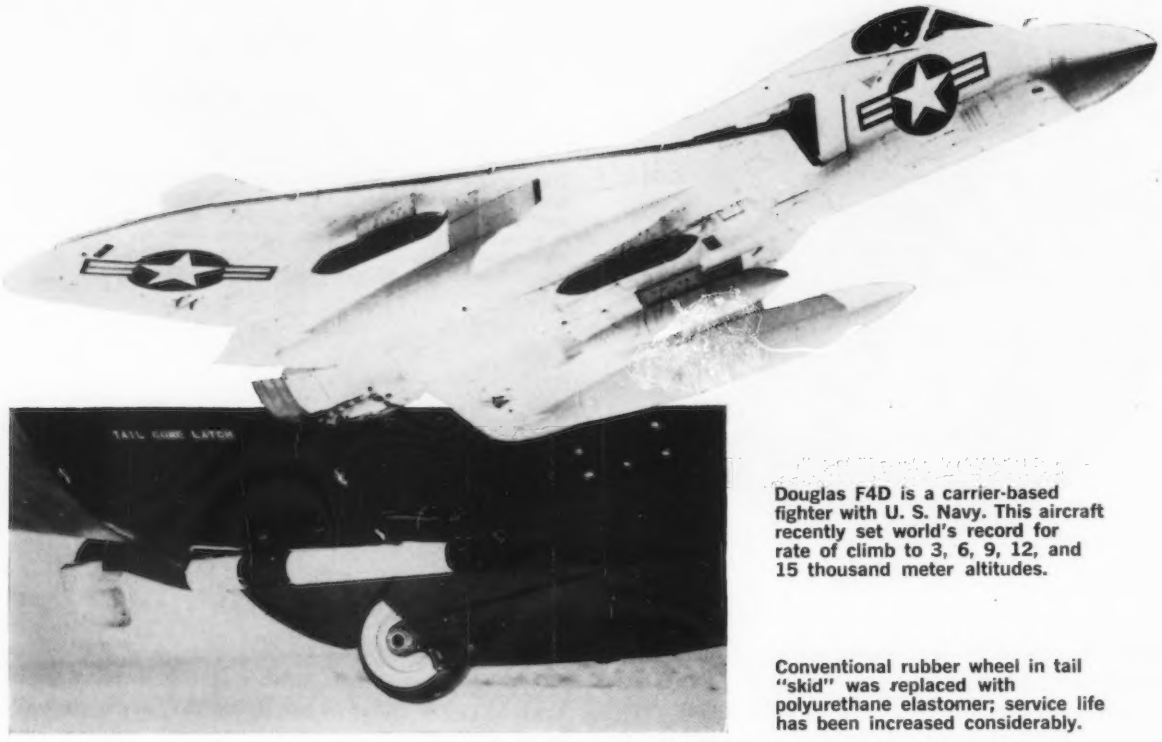
Other controls, although they have not been as problematic as the flying tail, are actuated in a similar manner. Ailerons and rudder also have artificial-feel units.

Yaw damper, which was not included on X-models is incorporated in the YP6M-1 and is planned for the production P6M-2 models.

An extremely noteworthy design feature is the double function of the hydroflap. While the plane is in the water the flaps can be operated in unison as a brake or "sea anchor," or they can be operated individually to assist in maneuvering the craft in the water. The use of the long afterbody-hull makes it important to have this additional directional-control at low "taxi" speeds.

In the air these same flaps act as speed brakes and cause very little change in trim. Attempting to land with speed brakes extended could prove disastrous so they are automatically retracted when flaps are extended and/or when throttles are fully retarded.

Control is achieved by a variable resistor, actuated by toe pressure on each rudder pedal. A permanent 28v dc actuator is used to operate the hydraulic valves connected to the right and left hydroflaps. A follow-up potentiometer is incorporated in each actuator and the deflection signal produced is coupled with the hydroflap position resistor to a bridge circuit and a micro-positioner relay. The two 28v dc hydroflap indicators on the pilot's subpanel indicate the position of the hydroflaps. In case of actuator or electrical failure, the hydroflaps can be closed by manually controlling a release lever in the auxiliary power unit compartment.



Douglas F4D is a carrier-based fighter with U. S. Navy. This aircraft recently set world's record for rate of climb to 3, 6, 9, 12, and 15 thousand meter altitudes.

Conventional rubber wheel in tail "skid" was replaced with polyurethane elastomer; service life has been increased considerably.

polyurethane elastomer

Disogrin material proves "brute for punishment" in airborne applications; abrasion resistance, resilience at high hardness promote in-plant usage

The operational and environmental demands in aircraft and missiles are so varied that no single material or class of materials could ever fill all needs. There is a great need for specialty materials, materials to fill particular needs. A class of materials finding increasing usage in airborne and production applications, where resilience at high hardness is essential, is sold polyurethane elastomer.

Polyurethane elastomer has excellent elongation, high resistance to abrasion and good tensile strength. This class of elastomer has a molecular structure which is readily manipulated to give a variety of properties to the end material without using additives.

Airborne Applications

Douglas Aircraft Co. uses a polyurethane elastomer known as Disogrin in the tail "skid" wheel of the F4D Skyray. This wheel is subjected to high impact loadings, severe erosion and abrading conditions, and abnormal chipping forces during the diversified landings required of naval aircraft, i.e., carrier arrested landings, carrier touch-and-go landings (bolters), field carrier landing practice (fclp), and normal field landings.

To utilize the aerodynamic braking effect, F4D aircraft perform landing roll out in nose-high condition, tail wheel often comes in contact with the runway. During fclp, and arrested landing the wheel often strikes the landing surface. On an aircraft carrier the steel arresting cable

PROPERTIES OF ELASTOMERS AND PLASTICS

	Chemical Name	Trade name	Mechanical Properties: Relative abrasian resistance: High	Medium	Low	Tensile strength, psi: below 1500	1500–4000	4000–8000	over 8000	Elong., %: below 300	300–500	over 500	Tear resistance	Service temp,. F: min: below −70	−40 to −70	over −40	max: below 212	212 to 275	275 to 500	Oil resistance
ELASTOMERS	Butadiene—isopropylene copolymer	Butyl			X		X				X		good		X			X		poor
		Neoprene			X		X					X	good		X			X		fair
	Silicone rubber	Silastic			X	X						X	poor	X					X	fair
	Urethane rubber	Adiprene		X				X				X	fair		X		X			good
		Vulkollan	X					X				X	good		X		X			good
		Disogrin	X					X				X	good		X		X			good
	Fluorinated Elastomer	Viton A			X		X				X		fair		X				X	good
		Kel F			X		X				X		fair		X				X	good
RIGID PLASTICS	Polyamides	Nylon Rilsan		X					X	X			good			X		X		good
	Fluoroethylene	Teflon			X		X			X			fair		X				X	good
	Polyester	Mylar		X					X	X			good					X		good
	Urethanes	Durethan		X					X	X			good				X			good

Data courtesy of Jean Pierre Abbat, director of research and development, Disogrin Ind. Inc.

severely chips large sections from ordinary tail wheels and causes a high change rate. Disogrin tail wheels have increased tail wheel life about 2 to 3 times that normally expected. In one test a wheel survived 58 fclp, 33 carrier arrestments, and 49 fielding landings before a small piece of the polyurethane compound was chipped off. After these 140 landings only 3/16 in. of the elastomer was worn away. A total of 5 polyurethane wheels averaged 46 landings per wheel; 6 rubber wheels averaged 28 landings per wheel.

Disogrin polyurethane elastomer grades have also been used as the liners for airborne oxygen containers. Liners are pressure molded in two hemispheres and cold bonded at the circumference. A jacket of glass cloth is applied to the surface for structural support. Completed assemblies are used as accumulators and are subject to pressure cycling from 0 to 150 psi. The polyurethane resists attack by oxygen, remains flexible without cracking.

The material is also used in gasket, seal, and wiper applications where temperature conditions are moderate (200°F). Resistance to hydraulic fluids, aliphatic solvents, and petroleum base fuels is good.

Production Use

An early and continuing application for polyurethane elastomer has been in contact wheels for belt grinding machines. Suppliers records show it outlasts neoprene 4 to 1 on turbine-blade grinding machines. In this application abrasion resistance, and the ability to be bonded to metal and subsequently contoured play important parts. Wheels are in use at Utica Drop Forge and Tool Co., Pratt and Whitney, Curtiss-Wright Corp., and General Electric Co.

Availability

Polyurethane elastomers are available in Europe as Vulkollan, in this country as Adiprene and Disogrin.

Various Disogrin grades are identified by the designators similar to DSA6865, where the letter prefix conforms to ASTM marking of materials of low-swell volume in hydrocarbon fluids. First two digits indicate durometer hardness (68), and last two digits indicate tensile strength in hundreds psi (650 psi). A varying range of hardness strength combinations is available.

✦

Dusting material cascades down from the Auster Agricola via the two slots positioned in the aircraft's belly. Note the ample track width, ejector exhaust system and heavy cabin structure.

agricultural aircraft design

presents difficult size-weight problems; British look at both high and low wing models

by Ronald A. Cole

Agricultural aircraft presents to its manufacturer one of the most difficult specification problems ever met with small size aircraft. In brief, they have the problem of producing an inexpensive easily-maintained aircraft which has to be very rugged.

Overall requirements for the type of aircraft to be employed vary from one continent to the next. In the more compact countries like Australia, New Zealand and the whole of Europe, pure crop dusting aircraft can become a financial liability. As a result operators seek the more universal aircraft which can also do transportation work.

Low-Wing Type

After very careful study of the problems posed by applicating aircraft, Auster Aircraft Ltd. produced a very practical low wing monoplane of mixed metal construction. Powered by a Continental 0-470-M2 engine giving 240 hp at take off and driving a Met-L-Matic propeller, the Agricola can lift 1500 lb of phosphate. It is possible to fit spray gear for fluid dispersion. Small cargos, or two people, can be carried when ferrying.

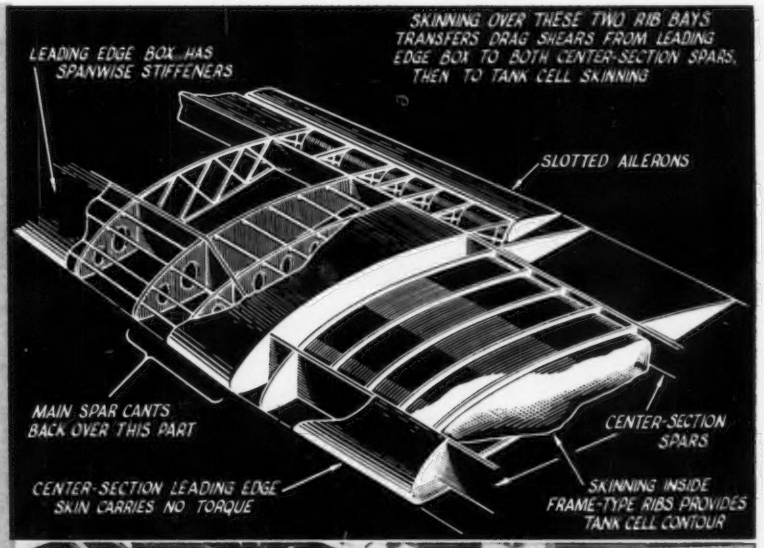
The fuselage is made in two sections which join over the wing center section with mating lug and fork end fittings. Both parts are welded steel tube frame structures assembled in simple holding jigs. Correct alignment of the front and rear sections is obtained by adjustment of the threaded shanks of the lugs, which are afterwards

locked in position. A strong superstructure carries the flat windshield panels and doubles as a crash pylon. It has been placed well forward of the pilot. Despite the weight penalty the windshield panels are of thick safety glass.

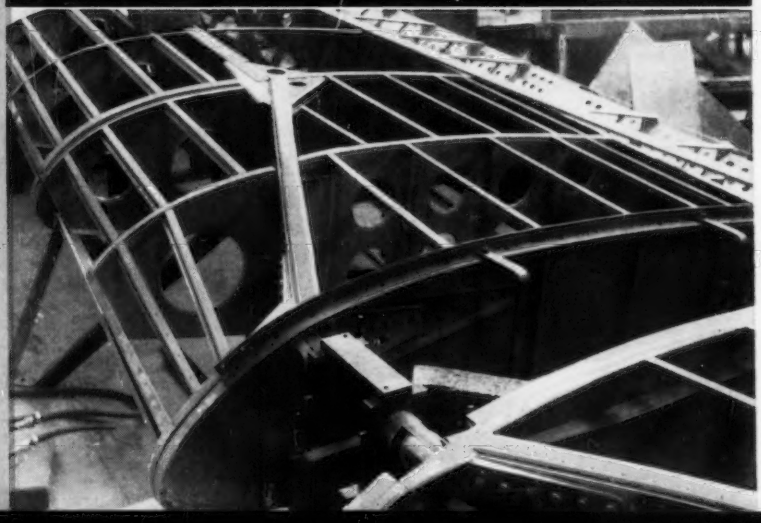
Behind the cockpit is a large hopper bay which straddles the CG position. It feeds into two variable gates running fore and aft under the fuselage. When fully opened, these can pass eight inch pieces of material. A load of 1700 lb can be dumped in five seconds. These limits are set by a mandatory government requirement. A glass fiber funnel, circular in section leads up to the roof of the cabin through which charging takes place. Like the flaps and the brakes the hopper gates are hydraulically operated.

Practical experience has shown that phosphate powder gets inside an aircraft and that a small amount of moisture is sufficient to make it adhere to everything. Apart from the danger of it clogging control fairleads, hinges and pulleys, to say nothing of added weight, it will set up a corrosive action that can very soon destroy the whole airframe. To counter this, Austers have sealed their structure into airtight compartments wherever possible. Thus the rear fuselage, wing outer panels, tail surfaces and all controls are sealed volumes. Small filters have been placed in the fabric covering to allow the compartments to breathe and relieve pressure differential due to change of altitude. As an extra precaution all parts of the airframe are protected with a special acid resisting paint specially developed for this class of aircraft by Cellon and Titanine.

Over the center section of the wing, two tension spars are spaced by frame type ribs. These provide support for an inner skin which forms the tank walls. Apart from keeping the fuel and spray-type bag tanks in shape, this skin also carries drag and some torque shears. Square section


SKINNING OVER THESE TWO RIB BAYS TRANSFERS DRAG SHEARS FROM LEADING EDGE BOX TO BOTH CENTER-SECTION SPARS, THEN TO TANK CELL SKINNING
LEADING EDGE BOX HAS SPANWISE STIFFENERS
SLOTTED AILERONS
MAIN SPAR CANTS BACK OVER THIS PART
CENTER-SECTION SPARS
CENTER-SECTION LEADING EDGE SKIN CARRIES NO TORQUE
SKINNING INSIDE FRAME-TYPE RIBS PROVIDES TANK CELL CONTOUR

This drawing shows the two spar center section and its connection to the torsion box of the outer wing on the Agricola.



A photograph which shows the offset spar of the Agricola wing outer section.

agricultural aircraft design . . .

continued

steel tube bent to the correct curvature forms the top and bottom of the frame ribs. Hollow steel rivets tie the inner tank skin to the rib inner face while a novel wire staple holds the fabric on the outer face. Although the leading edge is skinned to form a 'D' nose, it does not contribute to the torsional stiffness. Landing gear struts are attached to the front spars by substantial castings; both the fittings and struts are interchangeable. Simple split flaps are attached to the rear spar.

The outer wing panels are basically single spar structures although there is a secondary spar to carry aileron hinges and their loading. A torsion box leading edge carries some bending moment in spanwise stiffeners and the rest in the tension field beam. To provide sufficient torque box area over the outer span the beam cranks back over the first two bays of the outer panels. Leading edge riblets are of the pressed and pierced type while aft of the spar they are simple cross trusses. Assembly is carried out in a simple jig which holds the front and rear spars at the correct dihedral angle. The ribs are then fixed in position before skinning and the insertion of various fixtures.

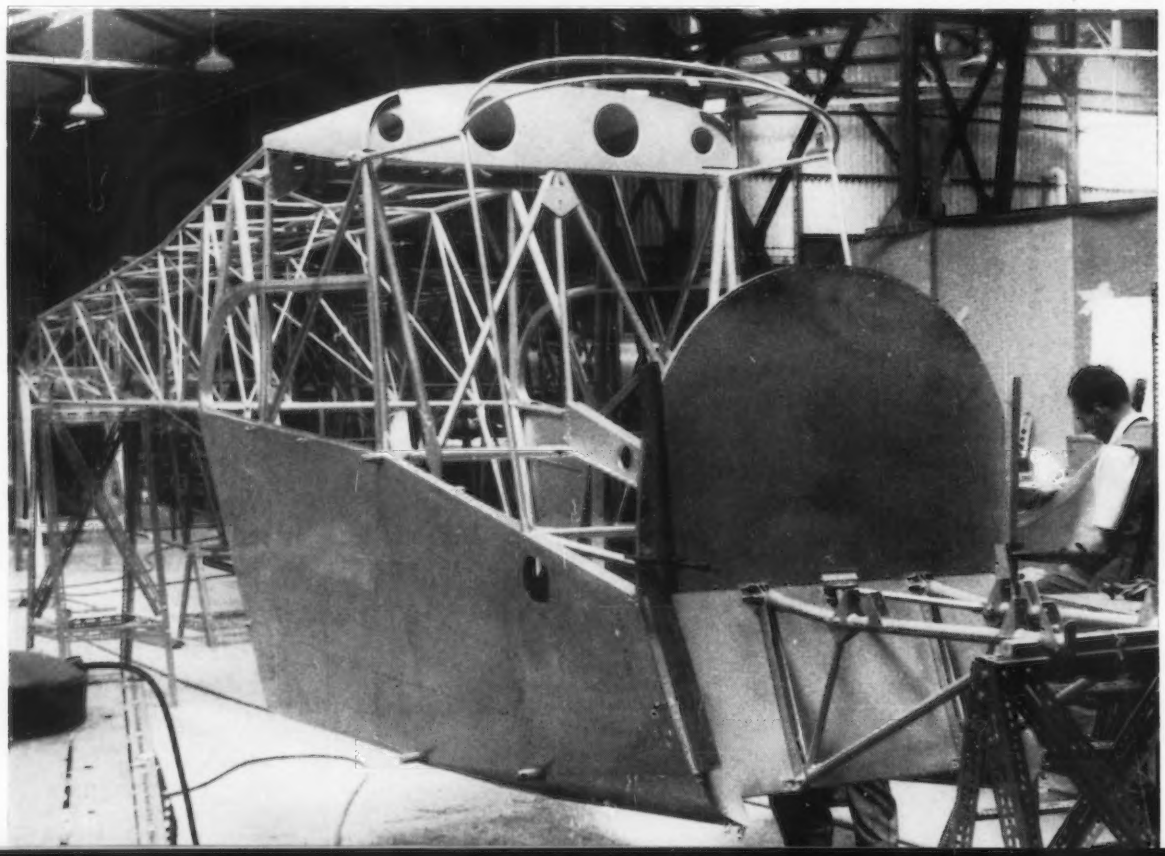
Aerodynamic design is quite normal, NACA 43018 profile is used across the parallel center section and progressively changes over the outer wing to NACA 23012 at the tip. This part of the span also includes a three degree washout and seven degree dihedral angle. Ailerons are of the slotted type and are extremely powerful in action. Span is 42 ft area 255 sq ft and aspect ratio 6.93. A 10 per cent symmetrical slab stabilizer of 45 sq ft is fitted at the fin post position.

High-Wing Type

The Edgar Percival EP.9 is a classic example of a general utility aircraft designed with an eye to agricultural work. It is a high-wing, strut-braced monoplane having a pod and boom fuselage. Structurally the EP.9 is very similar to the Agricola having a fuselage of welded steel tube. This material has a UTS of 100,000 psi in the as-drawn condition, reducing to 66,000 psi when welded. Thin light alloy sheeting covers the pod section of the fuselage for durability only; no stresses are carried by the sheet.

Three transverse frames which form the basis of the fuselage are welded up in vertical

The basic fuselage structure of the Percival EP.9. Skinning is of a light gage and carries no stress.



The Percival EP.9 is a pod and boom design having a moderately high aspect ratio wing with slotted flaps and ailerons which can be drooped.

jigs. These are then placed in holding jigs while the longitudinal members are put into position. The boom part is made as a separate unit and then joined to the forward section. After inspection and removal from the jig the whole framework is painted prior to addition of equipment and details.

Layout of the pod is a lesson in space economy and use. The engine bay ends at the first frame which is faced with a thin sheet of galvanized steel to make a fireproof bulkhead and form the cockpit front wall. Seating two, the cockpit is positioned above the engine level and is exceptionally roomy; a great help in this direction has been the placing of the instrument panel over the rudder pedals. Eye level is at the same height as the wing leading edge. Cabin volume extends forward under the cockpit floor to the engine firewall. It will hold four people or alternately, freight. A door in the side allows entrance for passengers and the rear fairing opens to allow cargo loading. A metal faced wood sandwich is used for the cabin floor. Either spray tanks or dust hopper can be fitted in the cabin; the hopper feeds through a hole in the flooring to a venturi dispenser.

Basis of the wing is a single tension beam which, assisted by a single strut, carries all bending and shear loads. Over most of the span the shear web is of 22 gage material changing to 24 gage near the tip. Booms consist of small 'L' section extrusions riveted to the web on one side over most of the span but doubled up in the region of the strut attachment to form an 'I' section spar. The spar is produced complete with root-end fitting and then held in a simple vertical jig which also positions the pressed ribs on either side of it. A simplification is afforded by the ribs forming the vertical stiffeners when they are in position. Light alloy tubes run along the leading edge and trailing edge which is in effect the lip of the slotted flaps and ailerons. Small gusset castings are bolted through the spar booms, top and bottom, and riveted to the ribs to provide spanwise shear rigidity. These are important members. The two-cell box is so formed that when the light gage covering is put on, it takes all drag-shear as well as the torque. No lift-bending loads are carried in the skin.

Interconnection between the flaps and ailerons causes the ailerons to droop when the flaps are lowered. There is no wash-out across the span which has a parallel chord. It is anticipated that the limited aileron droop will confine initial stall to the center span area. Span is 43.5 ft and the aspect ratio is 8.3; high for this class of aircraft and doubtless responsible for the rapid take-off performance. Airfoil is basically an NACA 6 series laminar flow type and has a thickness to chord ratio of 12 per cent.

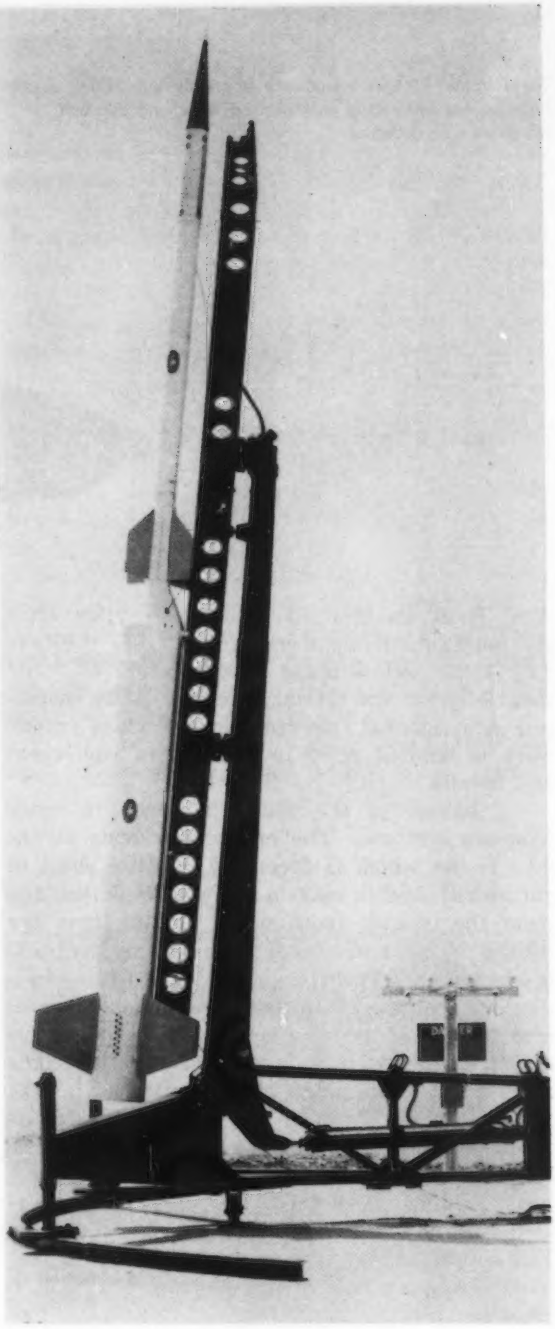
Simplicity has been designed into the airframe wherever possible. To this end the struts are of oval section tube rather than streamline section so that they can be interchanged. Shock absorption is via rubber blocks in compression on all three parts of the tailwheel undercarriage. All flap and control operations are through cable and mechanical linkage. The Lycoming GO-480 engine gives a maximum of 270 hp and drives a variable pitch Hartzell propeller.

◆

atmospheric soundings in Arctic use

proven rocket techniques

IGY officials use Nike-Cajun, and Aerobee to gather temperature, pressure, wind data; observation techniques tested at White Sands



Nike-ASP is typical of modified Nike missiles that are being used in IGY sounding of upper atmosphere.

During the International Geophysical Year (IGY), rocket soundings are measuring temperature, pressure, density, and winds at high altitudes in the Arctic. By the end of the IGY these soundings should yield enough data to provide a good understanding of the dynamic processes of the upper atmosphere.

In the planning of the experiments, the philosophy was that only proven rocketborne techniques would be used. All techniques for observation have been tested at the White Sands Proving Ground and have yielded significant data.

Table 1 lists all experiments in the Arctic program and the location and number of launchings up to June 1958. All of the US experiments, except that using the grenade technique, depend on telemetry (radio transmission of data to ground stations) from the rocket. Interpretation of most of the data depends on a knowledge of the trajectory of the rocket as obtained by the Doppler-Velocity-and-Position (DOVAP) system. DOVAP establishes the trajectory by measuring phase differences in the arrival of radio signals from the rocket at three locations (see Fig. 1).

The Freely-Falling Sphere

This method of measuring the density of the atmosphere was developed by first using Aerobees and later Nike-Cajuns. In the present procedure, a 7-in. diam, 9-lb sphere is carried aloft.

This is ejected from the Nike-boosted Cajun. As it falls through the atmosphere, its drag is measured by means of an internal accelerometer (see Fig. 2).

Atmospheric density is calculated from the equation:

$$\text{drag} = \tfrac{1}{2} D v^2 C_d A$$

D = density of air
v = velocity of sphere
C_d = drag coefficient
A = cross-sectional area

The drag coefficients are known from scaled wind-tunnel tests at low pressures. Velocity is obtained by timing the free-fall from peak altitude of the rocket. It is therefore possible, with the measurement of deceleration to calculate D.

The altitudes for which the experiment is effective depend on the height from which the sphere is dropped, the ratio of the sphere's area to its mass, and the sensitivity of the accelerometer. The equipment now in use yields data for altitudes between 10 and 90 km. The accuracy is within 10 per cent of the true value throughout this altitude range; its primary limitation is uncertainty regarding the values of the drag coefficients. Pressures and temperatures may be derived from the computed densities.

The Rocket-Grenade

In the rocket-grenade experiments the temperatures and winds of the upper atmosphere are measured by means of explosions of charges carried aloft and ejected from Aerobees. The positions and times of the explosions in space and the times and angles of arrival of the successive sound waves at the ground are recorded by an array of microphones. (Figs. 1 and 3.)

The average temperatures in the levels between grenade explosions are calculated from the relationship:

$$C = \sqrt{\frac{\delta RT}{M}} = K (T)^{1/2},$$

where

C = the velocity of sound in the layer
δ = ratio of specific heats of air
R = gas constant
T = temperature
M = average molecular weight of air
K = constant over the altitude range

The average wind speeds and directions in the air levels between grenade explosions are determined by measuring the differences between the true positions of the explosions (obtained by DOVAP) and their apparent positions as given by the angles of arrival of the sound waves at the ground. Using this method, the measured temperatures are accurate to ±5°C and the winds to ±10 m/sec in velocity and ±18 deg in azimuth.

Ten Aerobees-Grenade firings have been successfully completed. Five winter firings and

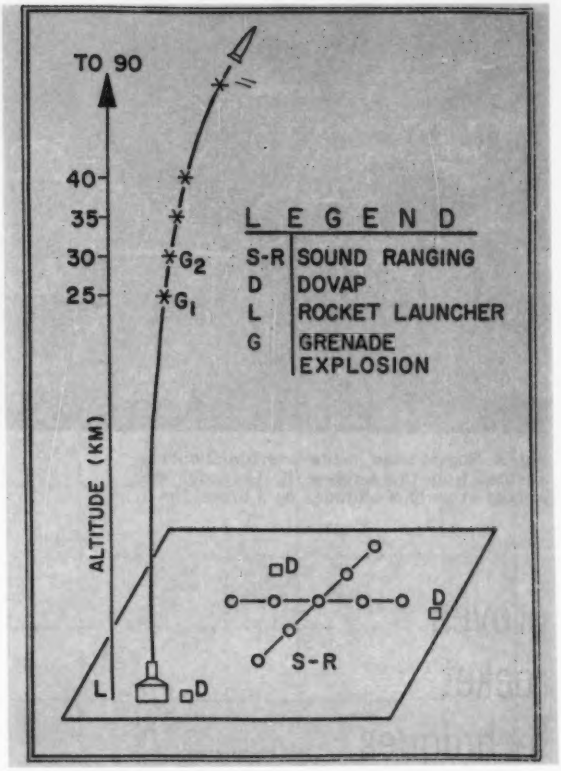
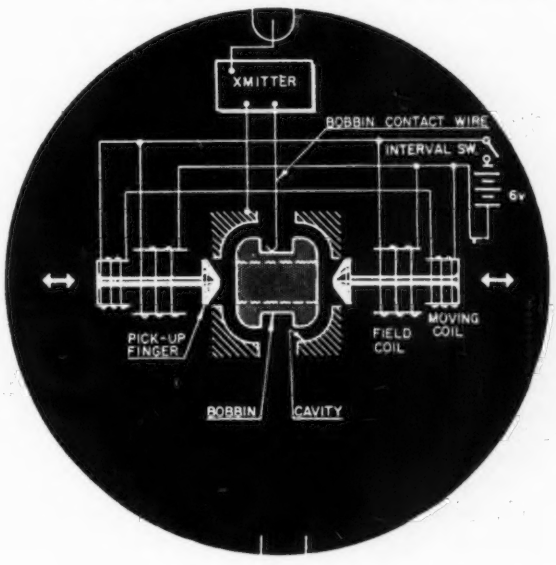


Fig. 1. Instrumentation for the Grenade Experiments is shown. The DOVAP stations track the rocket. The microphones determine azimuth and elevation of sound waves originating in high altitude explosions.

Fig. 2. Diagram of accelerometer in 7-in. sphere. When the sphere is in free-fall, the bobbin floats in the cavity. Drag acceleration causes the bobbin to move to the wall. Bobbin is centered and released and centered by the pick-up fingers.



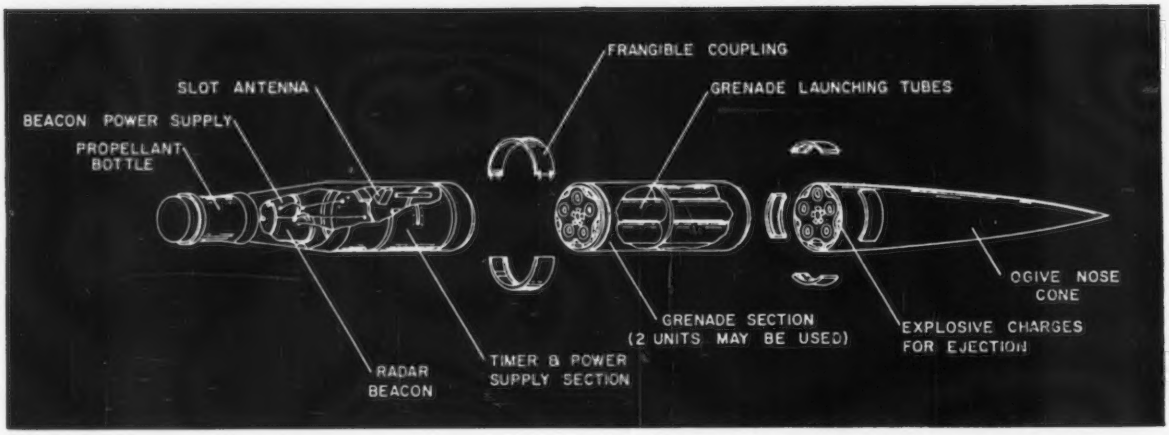


Fig. 3. Rocket used in the Grenade Shoots is adapted from the Aerobee Hi. Grenades are ejected at various altitudes by a preset timer.

Table 1. Arctic Meteorological Rocket Soundings

Experiment	No. Launched	Location	Time
Sphere	8	North Atlantic & Churchill	W, D
Grenade	10	Churchill	W, S D, N
Aerodynamic	6	Churchill	W, S D, N
Gauge	3	Churchill	W, S D, N
USSR	6	Franz Joseph Land	W, D

Time code: W—Winter; S—Summer; D—Day; N—Night.

proven rocket techniques . . . continued

five summer firings were made. Some were in the daytime, some at night; on January 27, 1958, firings were made at midnight and at noon to measure the day's variation of temperatures and winds up to 90 km.

Reduction of the grenade data involves the determination of the positions of each of the grenade explosions from the DOVAP records and the calculation of the angles of arrival of the sound waves. The calculation of the temperature and winds from these elements has been programmed on an IBM 650 computer, which speeds up the final steps of the reduction. However, the DOVAP reduction for positions is done by hand-counting the Doppler cycles, some 400,000 of them per launching; this takes several months.

The preliminary results are shown in Figure 4. A difference between the summer and winter temperature distributions throughout the entire altitude region is shown.

The temperature data obtained from radiosondes flown at the times of the rocket soundings are also plotted in Figure 4. The soundings overlap in the 30-km altitude region and the data match quite well.

Aerodynamic Experiment

In the aerodynamic experiment, a gauge mounted at the tip of the nose cone of the rocket measures stagnation, or ram, pressure. Other gauges measure pressure at the sides of the cone. Alphatrons are used for these pressure measurements on both Aerobees and Nike-Cajuns. The alphatron uses a radioactive source of alpha particles to ionize the residual air between two collecting electrodes.

Pressure at the tip of the nose cone is, of course, much greater than on the sides because of the high speed of the rocket. The ratio of these two pressures is theoretically related to the Mach number, the ratio of the speed of the rocket to the speed of sound in the surrounding atmosphere. As the velocity of sound increases with temperature, the experiment therefore makes it possible to calculate atmospheric temperatures. The results are valid up to about 100 kms.

As do all other experiments except the sphere experiment, the aerodynamic method needs detailed trajectory data before the pressure measurements can be used in evaluating other physical properties of the atmosphere.

Preliminary data from the six aerodynamic experiments indicate that between altitudes of 20 and 80 km in the Arctic, densities are 2-3 times lower than those measured previously at lower latitudes.

Gauge Experiments

These measurements of pressure and density (from which temperature may be derived)

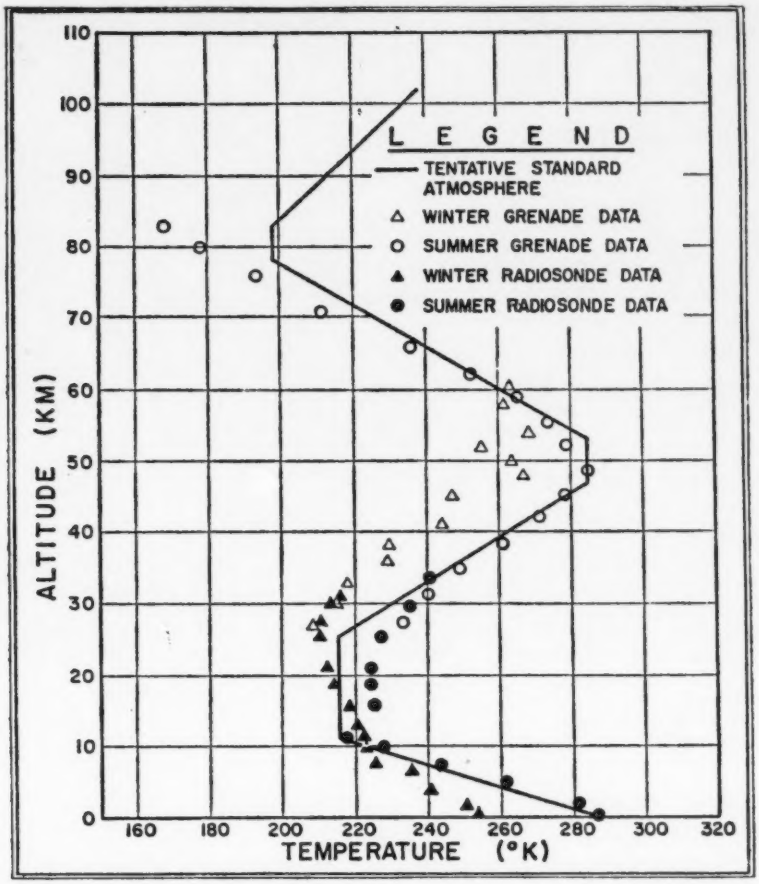


Fig. 4. Upper air temperatures obtained with grenade experiments are in general accord with those obtained by radiosonde.

are carried out as follows with Aerobee-Hi rockets. Pressure gauges of various pressure ranges are scattered over the surface of the rocket, measuring stagnation and cone pressures, and pressures elsewhere on the rocket. The gauges measure pressures from 760 mm Hg to 10^{-6} mm Hg.

Roll modulation, or the change in amplitude of the gauge output with roll of the rocket, appearing on the side-cone gauges also permits the determination of the atmospheric pressure at higher altitudes (10^{-7} mm). These Aerobees are sealed throughout to prevent interior gases from leaking out. This permits an accuracy of measurement approaching the limits of sensitivity of the gauges.

This multiple-gauge approach has made possible measurements to much higher altitudes than the other techniques. Its accuracies, as given by NRL, are:

	Altitude	Error
Pressure data	25-80 km	5-15%
	110-150 km	20-50%
Density data	30-80 km	2-10%
	110-300 km	20-200%

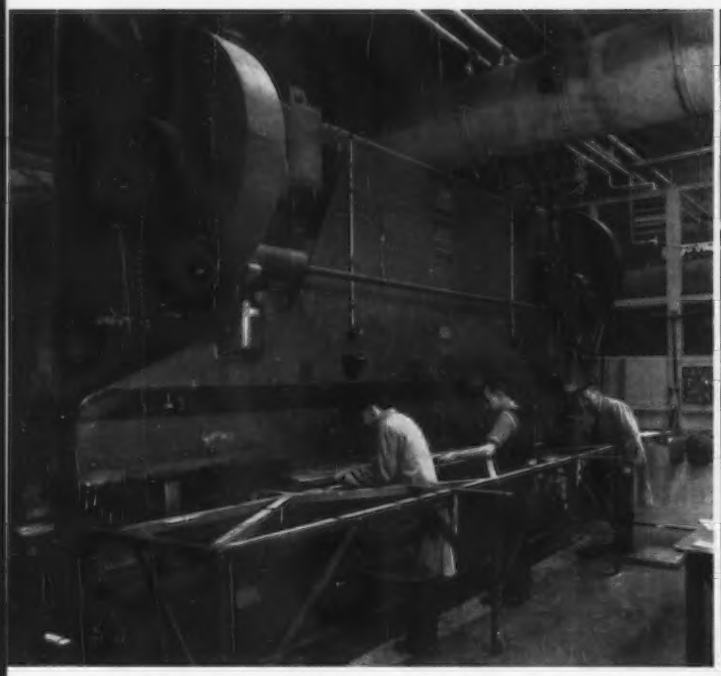
USSR Methods

The USSR is also conducting Arctic rocket-sounding programs during the IGY, using a meteorological sounding rocket to measure temperatures and pressures up to about 110 im. The USSR-IGY Committee has reported that between November 1957 and March 1958 six rockets were launched in Franz Joseph Land.

As described in Soviet literature, the instrumentation consists of thermal and membrane manometers for measuring pressure, and an electric resistance thermometer for temperatures. An interesting feature of this technique is the use of a parachute throughout the entire downward leg of the trajectory to orient and slow the separated instrumentation section in its fall.

Previously published USSR results for the upper middle latitudes show general agreement with US-IGY results in this field.

This report is abstracted from material furnished by W. G. Stroud, U. S. Army Signal Research and Development Laboratory, Fort Monmouth, New Jersey.



Corrugated sandwich fillers are produced on brake presses of the type shown here. This core is made in 10 ft long panels of seven different types and of varying gage and material.

A close up of the corrugated filler showing shape similar to an Acme thread profile

sandwich panel construction

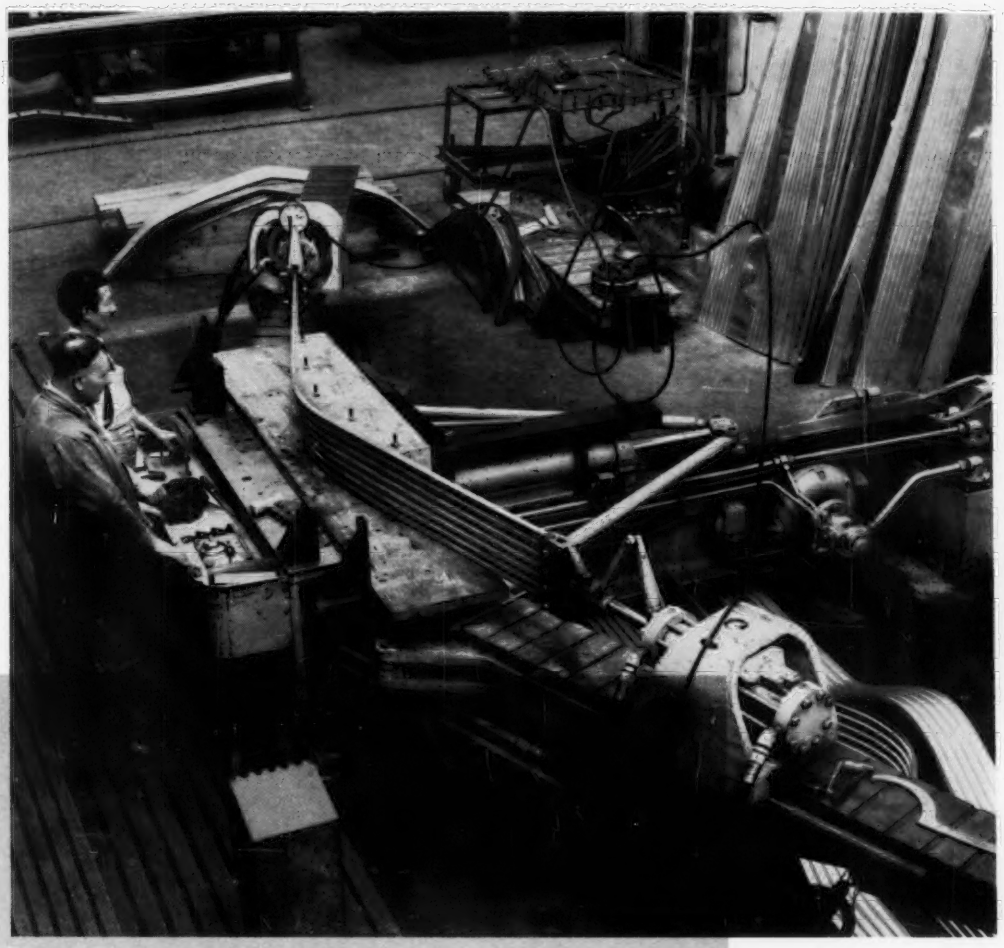
design, production, inspection considerations from a study at Handley Page

by Ronald A. Cole

The advent of large and high-speed aircraft promoted the use of extensive integrally-stiffened skin panels. Handicapped by the lack of large skin mills and other specialized heavy equipment, British designers resorted to sandwich-skin construction. In the particular case of Handley Page Ltd., an investigation was initiated to evaluate applications of various sandwich-skin designs.

As a kicking off point, a core material density of not more than 4½ lb/cu ft was specified together with an operating temperature range from −70 to +70°C.

Many types of fillers were assessed including balsa wood, impregnated paper, calcium al-



Shaping of corrugated cores is done on stretch-wrap machines using timber formers. Where single curvature across the waves is needed, it is hand induced and kept in holding jigs while the formed inner skin is attached.

ginate foam, impregnated cottons, linens and glass cloth. One of the best tested was 0.003-in. thick aluminum-foil honeycomb of 42,000 psi uts. Shear resistance was below requirements but it could be increased by beading each wall of the honeycomb during manufacture. It was found that with a certain corrosion-resistance magnesium alloy a core wall thickness of about 0.001 in. could be used. With Araldite No. 1 adhesive for bonding of faceplates a finished weight of about 1.8 lb/cu ft was obtained.

Tests showed that honeycomb-filled panels had many advantages and that a wider use could be made of them. However, there was a disadvantage in their mode of failure. Whereas the skin of a stringer-stiffened panel would buckle without failing, any buckle in a honeycomb-sandwich panel would lead to immediate failure. It was observed that when fully loaded such panels buckled into long waves just prior to failure, and this fact suggested the use of a different type of core; one that would space the plates and add to the bending stiffness to delay buckling.

A corrugated light-alloy core having a profile similar to that of an Acme thread and with the beads running along the panel provided the solution.

Corrugated stiffening provides shear resistance normal to the skin which can therefore carry high loading either as a beam or as a strut.

continued on next page

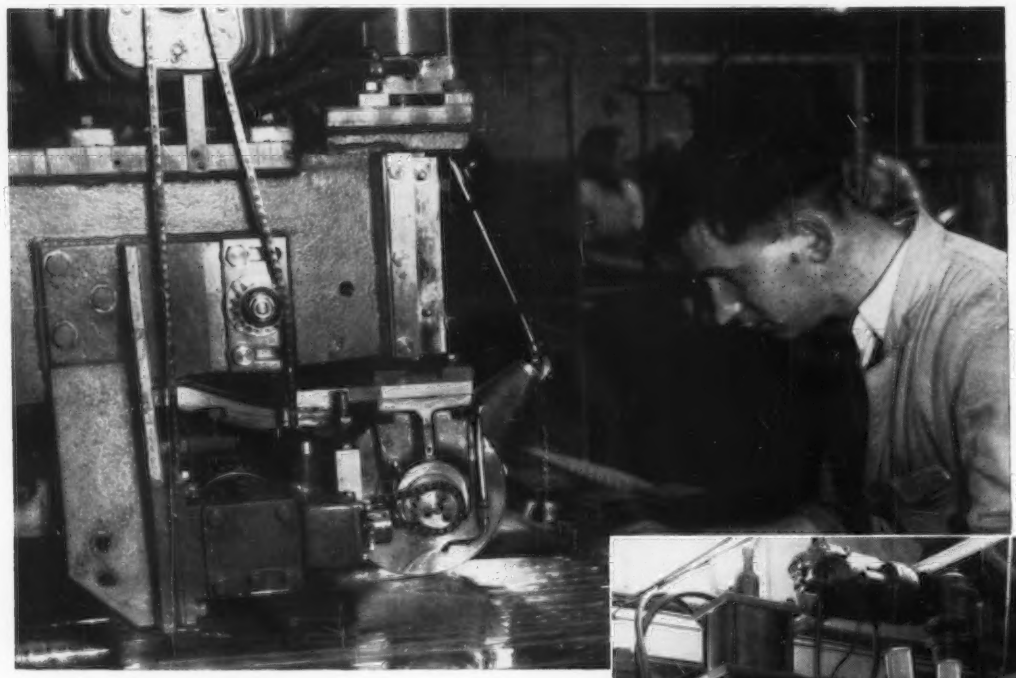
sandwich panel . . . continued

The faceplates are stiffened sufficiently to carry high shear loading without wrinkling, and the numerous individual cells within the skin add greatly to torsional stiffness. By varying the depth of corrugations along such panels section properties may be altered as required. It was also found that contour accuracy could be held within 0.025 in. and waviness to within 0.004 in./in.

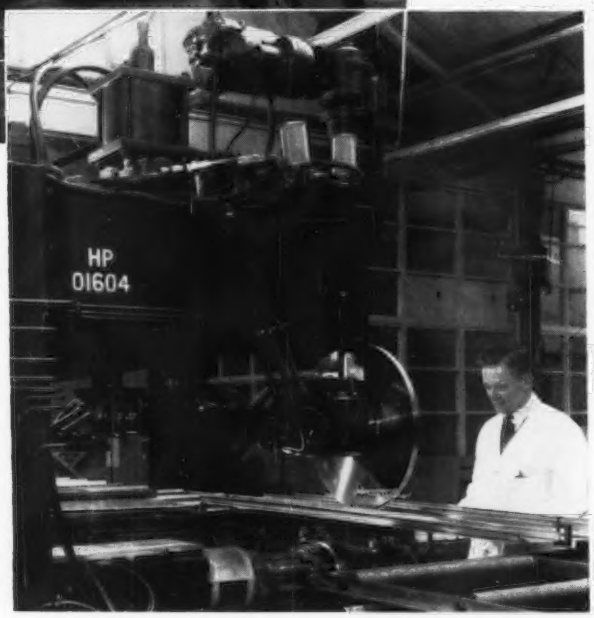
To promote a fine exterior finish it was decided to spot-weld the cores to the outer plates and use blind rivets to join the inner skin as a finishing operation. Spot welding identation is kept to 0.001 in. using large flat electrodes on the machines.

The assembled panels are inspected by X-ray. Experience has shown that examination of the radiograph will allow an accurate determination of strength as well as denote the presence of harmful defects. An extensive test program has also established the relationship between strength and weld diameter.

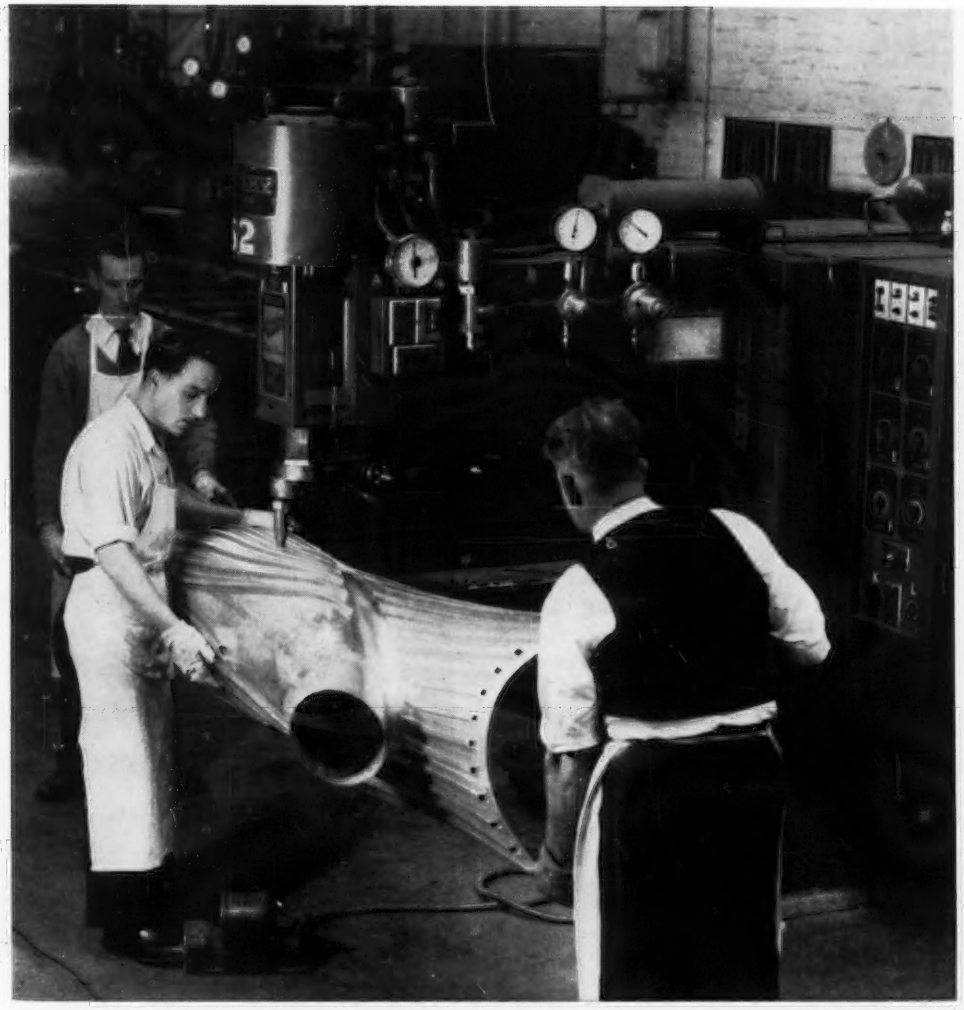
When Handley Page started using spot welds for primary structures, 100 per cent X-ray



Continuous resistance welds being produced with wheel-type electrode. Small jet of cooling fluid is fed against rim of electrode wheel.

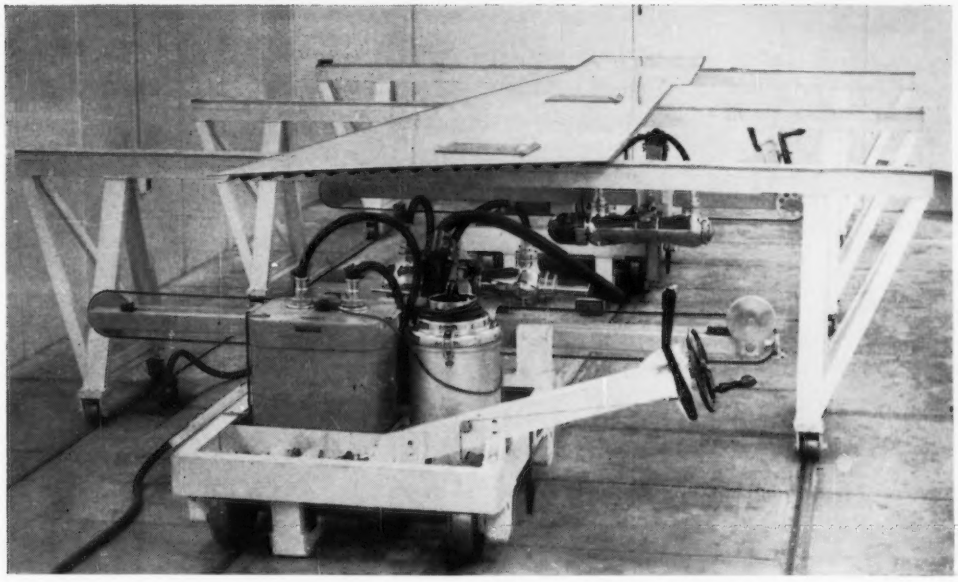


Large wheel electrode being used for joining Z-section stiffeners to face plate.



Hat-section stiffeners being spot welded to outer surface of intake duct. This method of attaching stiffeners to a body, then covering with another sheet gives cored structures where intricate curves are encountered.

X-ray inspection of spot-welded panel. Film packs are laid on panel, and traversing lamp-trolley arrangement provides exposure from below.



sandwich panel . . . continued

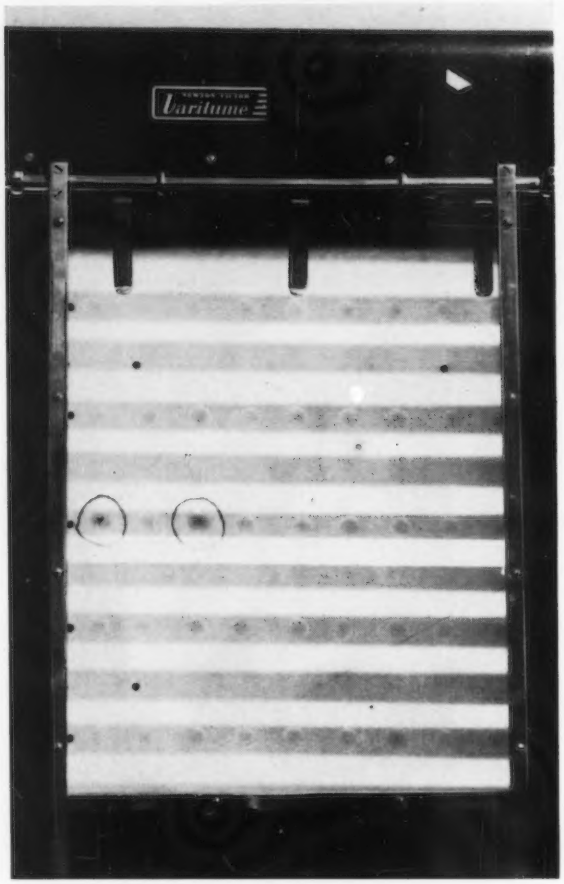
inspection was used. Cumulative experience later allowed the random statistical approach to spot-weld inspection. Panels with 2½ to 5 per cent defective welds are rejected. Rejection of the panels does not mean scrapping; they are inspected thoroughly, then returned to the shop for extra spots to be placed in the weak areas. All the new spots are later re-inspected.

Experience has indicated that efficiency of spot welding depends on the maintenance of the welding machine, and the accurate mating of adjacent parts. If the parts have to be forced together, heating is poor and some of the necessary forging pressure is needlessly dissipated. Thus, production control centers around weld quality and accuracy of manufacture of the cores. Testing has established the best setting for each welding machine and combination of materials and thicknesses. This information is embodied in comprehensive instructions for each type of operation. Setting is entrusted to the foreman or his lead man, so the operator is left purely responsible for working his machine. The signature of the shop inspector is required to insure the proper settings before each operation.

To insure satisfactory operation, three test pieces are welded and tested to design load. These welded pieces are tested to destruction and the results entered on a quality control chart for that machine. Such test pieces taken at regular intervals throughout the day, and plotted on a graph insure weld quality on a continual basis.

Sheets of core are produced on standard brake presses fitted with automatic feed so that a close control of pitch and profile can be maintained. To simplify design and production the firm has standardized on seven different types of core. These are all made in 10-ft lengths from several gauges and material specifications. Simple wooden templates are used for checking accuracy of profile.

Where simple curves across the waves are needed the core and outer skin are welded together in the flat condition, then they are hand-bent to fit in the holding jig. Attachment of the pre-formed inner skin is sufficient to maintain the shape. When curvature along the corrugations is required, curvature of the core is obtained on a stretch-wrap machine. The pre-formed outer skin is then welded on. Inner skins have to be attached by high shear, hollow blind rivets. It is



Radiograph mounted in viewer reveals two defective spot-welds encircled by inspector.

not always necessary to use sheets of core material to form a sandwich, often channel strips of the drawn type may be used. Where double-curvature panels have to be made this is usually the case; the strip lengths are formed separately. Spar shear webs may need a more continuous type of stiffener adhesion, in which case strip welds using wheel electrodes are employed.

Considering the close control of production and the radiographic inspection process it would be natural to think that higher than normal production costs are incurred. In practice it has been found cheaper provided less than 25 per cent of the welds are inspected; Handley Page practice is to check between 10 and 15 per cent of the spots. Because of heating difficulties when bonding metals thicker than 0.05 in., Handley Page engineers maintain that spot welding is superior when used on skins 0.05 in. and thicker. Also during high-temperature operation and in moist atmospheres, bonding loses some strength and as yet no satisfactory inspection process for bonded structures has been devised.

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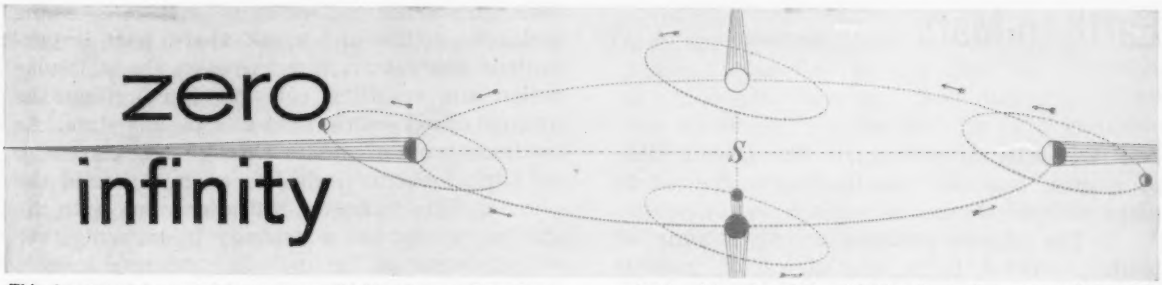


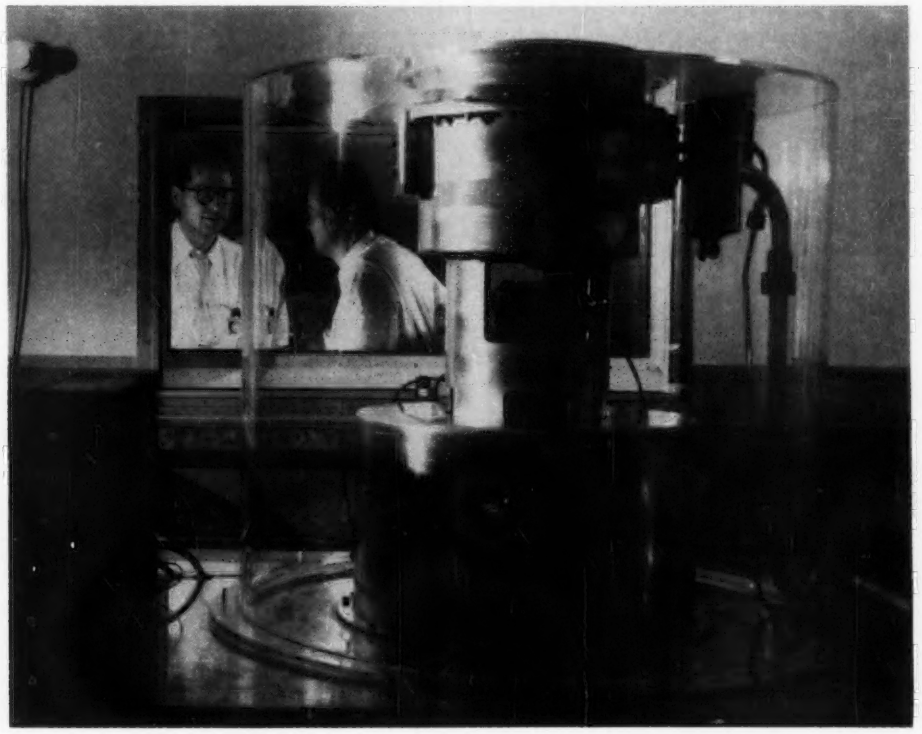
This department is created to encourage thinking in new dimensions; thinking that is free of the often constraining influence of immediate difficulties. Technological progress is to a great extent based on departures from the conventional or the status quo. That which is considered illogical or impossible to accomplish, has and always will be so only within the limited compass of accumulated knowledge up to a particular date. Speculative thinking is man's most precious asset. It is hoped that this department will provide an outlet for such thinking and will serve to stimulate further ideas. The implications of the symbolism for this department head are that: while the immediate worth of a concept may range from nil to infinity, its true value will only be determined in the ultimate.

Earth-to-Mars flight

does "magnetic pinch plasma engine" have the powerplant capabilities?

A "magnetic pinch plasma engine" could produce sufficient energy to propel a 35,000 lb space vehicle for an unmanned, one-way reconnaisance flight to Mars. The 34,600,000 mi trip would terminate in an orbit 310 mi distance from Mars.

The engine being investigated by Republic Aviation for this mission is based generally on



Magnetic pinch plasma engine, forerunner of the engine which might propell a space vehicle from Earth orbit to Mars is evaluated at Republic Aviation Corp.

two new scientific principles: The plasma state of matter, and the "pinch effect" achieved in magneto-hydro-dynamics.

The plasma state is a fourth state of matter, created by a breakdown of gaseous molecules into positive and negative particles (protons and electrons). The effect is achieved by setting the molecules in rapid motion; Collisions which occur between molecules release the particles from the bond which holds the molecule together.

Magneto-hydro-dynamics is the study of the interaction between a moving fluid capable of conducting electricity (the plasma) and a magnetic field.

The pinch effect is achieved by the discharge of electrical energy across two disc-shaped electrodes separated by a gaseous medium.

Method of Operation

It has often been suggested that electrical propulsion systems could accelerate propellants to very high efflux velocities, and therefore considerably reduce the mass ratio of a space vehicle (initial total mass of vehicle plus, fuel, divided by final total mass).

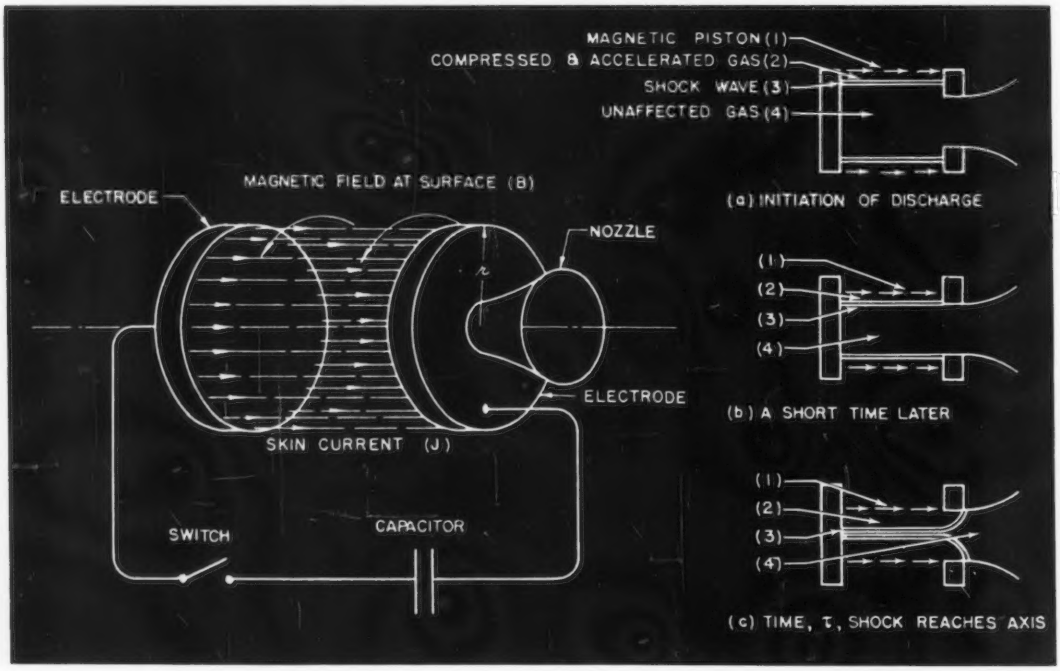
In the Republic engine, an electrical current is passed through oxygen, or similar gas. This starts the molecules in motion. As the molecules collide and break apart, heat is generated. The heat in turn increases the molecular action and resulting collision, building up the amount of oxygen changed to a plasma state. As electrical current passes through the plasma, a cylindrical magnetic field is created around the plasma. This magnetic field interacting with the electric current has a tendency to draw together at the center of the cylinder, reducing it to a double cone shape. The plasma is thus "pinched." The thin shell of current surrounding the plasma is driven inward at very high speeds (100,000 ft/sec) and acts as a cylindrical magnetic-piston. This "piston" effect causes a shock wave to run ahead, thereby raising pressure and temperature of the plasma further.

A "hole" is cut in one of the electrodes and a nozzle attached to allow the shock wave to be emitted in a controlled pattern. The radial kinetic energy caused by current and gas rushing to the "pinch" is thus converted to axial kinetic energy for propulsion. Obviously very careful attention is directed to electrode and nozzle design to achieve the desired effect.

The electricity necessary to produce the magnetic pinch is derived from a turbine generator which converts nuclear heat into electrical power.

The engine in its present configuration is designed only as a power source for a vehicle that has been propelled to an earth orbit by some

Fig. 1. Linear discharge tube with nozzle. Three stages of pinch are shown at right.



more conventional means. The pinch plasma engine would provide escape velocity and energy for the vehicle to reach a Mars orbit after 6 mo to 1 yr travel time.

The plasma engine differs from the proposed ion engine which shoots out negative and positive particles in separate streams, since the plasma engine uses intermingled particles in a single stream. The major advantage of the plasma engine lies in its high thrust potential.

The magnetic piston formed by the interaction of electrical current and magnetic field acting radially inward to form a construction, is a thin cylindrical shell and the pinched current is confined to this thin shell. Three stages of pinch are shown in Fig. 1, illustrating how the shock wave and magnetic piston move progressively inward. Fig. 2 shows how proper electrode design permits the shock wave to expand out of the nozzle to eliminate shock deflections at the axis of the electrodes.

Outside the shell, the density and thus the pressure is negligible, and the pressure difference through the shell (hence the inside pressure) is supplied by a gradient of the magnetic field. The nozzle electrodes are considered to be of uniform cross-sectional area throughout the annular path.

The width of the annular path is small enough compared to the average radius of curvature of the path so that one dimensional flow through a constant cross-sectional area can be considered. The travel of the cylindrical magnetic piston is essentially limited to the radial region permitting the use of the pressure equation $P2 = yI^2/_{8\pi}2rp3$. The shock wave driven out ahead of the magnetic piston is considered to be infinitesimally thin and the RanKine - Houghoniot equations, simplified for very strong shocks, can also apply. The entire process is considered quasistatic so that at any time the conditions of the gas between the magnetic piston and the shock wave are uniform. The gas ahead of the shock wave is unaffected. Ideal gas equations are considered to hold even though the temperatures can reach values for which the ideal gas laws are questionable.

Mass Ratio and Electric Propulsion

The equation of motion of a powered vehicle in space is given vectorally as:

$$\vec{F} - \vec{F_g} = m\vec{dv}/dt \qquad (1)$$

Powered flight in space generally involves changes in the vehicle orbit about a centrally located gravitational body and the gravitation force. Fg, in the direction of the resultant velocity change, dv, is small compared to the propulsive force, F. This is especially true if the propulsion force is impulsive so that it is large when compared to the gravitational pull on the vehicle. When propulsion is achieved with the electro-magnetic pinch, the propulsive forces are impulsive.

The final velocity has been called the "characteristic velocity" and with a series of impulsive forces the intermediate values of mass cancel in the logarithmic term, so that the final characteristic velocity is a function only of the initial and final mass of the vehicle. This ratio of initial to final mass, is a very important performance criteria of space engines, and the discussion below is concerned with the minimization of mass ratio.

When fuel (oxidant plus oxidizer) is consumed in a space engine, the energy made available is converted to kinetic energy of a propellant.

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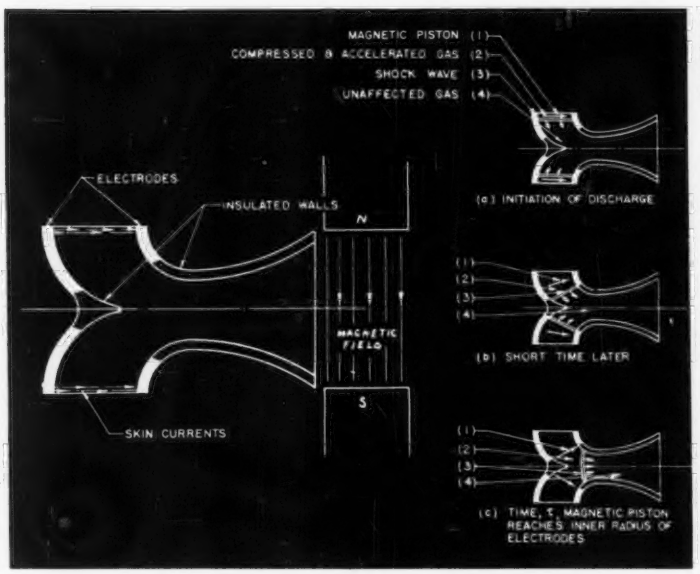
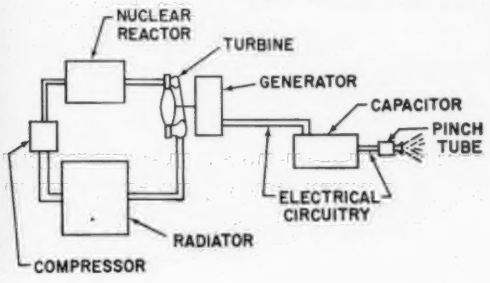


Fig. 2. Improved version of electrode design. Sketches at right show how shock wave should travel when it expands out through the nozzle.

Fig. 3. Diagram of overall eletromagnetic pinch engine.



Earth-to-Mars . . . continued

Three general possibilities have to be considered. The available energy, usually in the form of heat, is converted to kinetic energy of:

a. All of the fuel.
b. Part of the fuel, which obtains high propellant velocities, the remainder separated from the vehicle without contributing thrust.
c. All of the fuel plus additional inert mass to achieve low propellant velocities.

From the point of view of mass ratio it is inefficient to attempt an increase in propellant velocity by concentrating the available energy in part of the fuel, as in (b) or to attempt to increase propellant mass flow with consequent reduction in propellant velocity.

The conclusion obviously is that the optimum use of a fuel is to convert all the available energy to kinetic energy of the fuel, the fuel being the propellant as well as the energy source.

Since the available energy is generally in the form of heat a direct conversion of heat to kinetic energy would be the optimum system. One practical limitation of this energy conversion is the maximus temperature permissible in the system. In some cases, because of this limitation, intermittent or pulsed operation may prevail over a steady flow.

With a chemical source of energy, a steady flow engine (as a chemical rocket) would be limited to values of specific impulse of the order of 400 sec. This limits the exhaust velocity of the propellant to about 12,900 ft/sec for oxygen mixtures. Based on the previous discussion, no advantage is gained by attempting to increase this value by interposing electromagnetic or electric acceleration of part of the products of combustion.

With the use of a nuclear energy source, the mass-ratio criteria indicates the desirability of increasing propellant velocities far beyond the limit attainable with chemical combustion. A nuclear rocket, with hydrogen as the propellant, could theoretically reach a specific impulse 4 times the value available from combustion. The associated ideal propellant velocity is 51,600 ft/sec as compared to 12,900 ft/sec for chemical rockets when both systems have the same maximum temperature limitation.

An electric or electromagnetic propulsion device with a nuclear energy source would result in much greater propellant velocities, thereby reducing the required mass-ratio. The remaining question, however, is the weight of the components required to achieve these high efflux velocities.

It has become obvious, from unpublished studies, that it is not efficient to attempt conversion of electrically stored energy into kinetic energy of the plasma in one pinch. It will probably take a minimum of six pinches or three complete waveforms of voltage and current. Either the stored energy in the capacitor can be made to operate 6 pinch tubes in rapid succession with the use of a novel switching device, or a single pinch tube can be made to aerodynamically resonate with a connecting plenum chamber so that six pinches can occur successively during the period of a single capacitor discharge. At present the latter method is favored and the calculations below are based on this mode of operation.

COMPARISON OF MASS RATIOS FOR MARS MISSION

POWER PLANTS UTILIZED	REQUIRED MASS-RATIO
CHEMICAL ROCKET ONLY propellant vel. = 3.92 Km/sec	76.0
NUCLEAR ROCKET ONLY propellant vel. = 15.7 Km/sec	2.95
ELECTRIC SYSTEM ONLY (Nuclear energy source) propellant vel. = 46.9 Km/sec	1.45
CHEMICAL ROCKET to Earth orbit (621.3 mi), NUCLEAR ROCKET from Earth to Mars orbit	12.00
CHEMICAL ROCKET to Earth orbit (621.3 mi), ELECTRIC SYSTEM from Earth to Mars orbit	7.95
NUCLEAR ROCKET to Earth orbit (621.3 mi), ELECTRIC SYSTEM from Earth to Mars orbit	1.96

As a representative mission a one-way journey from the Earth's surface to a Mars orbit of 310 mi above the Mars surface is considered. The characteristic velocity for the journey is 16.96 Km/sec. If one power plant puts the vehicle in an Earth orbit of 621.3 mi above the Earth's surface, this requires a characteristic velocity of 7.36 Km/sec and we assume that from an Earth orbit to the Mars orbit requires 16.96 minus 7.36 or 9.60 Km/sec.

Mars Reconnaissance Vehicle Performance

The vehicle is considered to takeoff from a 621.3 mi Earth orbit and to cluminate in a 310 mi Mars orbit. The characteristic velocity for such a mission is 10.03 Km/sec. Considering the propellant velocity to be 46.9 Km/sec the mass ratio is 1.61.

Engine & Structural Weight (Excluding Capacitors)	11,000 lb
Capacitor Weight	5,000 lb
Total Engine & Structural Weight	16,100 lb
Payload Weight (Guidance & Information*)	6,000 lb
Fuel Weight	13,400 lb
Total Take-off Weight	35,500 lb
Change in Vehicle Velocity in First Day	273 ft/sec
Estimated Travel Time	¾ year

*The vehicle will be equipped to photograph Mars and to relay this photograph to Earth.

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AIRCRAFT & MISSILES MANUFACTURING DIGEST OF RECENTLY PUBLISHED TECHNICAL MATERIAL

producibility REVIEW

DESIGN

AVRO ARROW DESIGN. *Aerop.*, (October 10, 1958). 3 pp. Design background and modifications reviewed.

TWO ENGINE CONCEPT KEY TO F4H-1 DESIGN. G. Lewis. *Av. Wk.*, (October 13, 1958). 3 pp. Overall design features are discussed.

LEAF SPRINGS SIMPLIFY DESIGN OF RAMJET HELICOPTER ROTOR HEAD. *Des. News*, (September 1, 1958). 2 pp. Design details given of Holland's Kolibrie helicopter.

SMALL ENGINES KEY TO ICBM ACCURACY. I. Stambler. *Space-Aero.*, (October 1958) 2 pp. Design details of Rocketdyne's Vernier engines shown.

HU-1 IROQUOIS. H. Gaylord. *AHS Newsltr.*, (October 1958) 9 pp. Comprehensive coverage of the Bell HU-1 helicopter from development, design, performance, and serviceability aspects.

C-133 CARGOMASTER. *Flight.* (September 26, 1958). Discussion of general design features with cutaway sketches of structure and landing gear arrangement.

MATERIALS and PROCESSES

301 STAINLESS MODIFIED FOR 800 DEG F AND UP. D. B. Roach, A. M. Hall, R. Sergensen, and A. R. Stargardter. *Space-Aero.*, (October 1958) 3 pp. Data given on MicroMach, a cold-rolled steel with promising properties in the 800-1200 deg F range.

POWER-ROLL FORMING: MACHINING WITHOUT CHIPS. J. N. Heater. *Tool Engr.*, (October 1958) 4 pp. Characteristics, applications, and basic theory of process are given.

B-58 FEATURES ADHESIVE-BONDED STRUCTURES. W. K. Bailey. *SAE Journal*, (September 1958). 3 pp. Discussion as to why, where, and how these are used.

CONDENSED REVIEW OF SOME RECENTLY DEVELOPED MATERIALS. *Mach.*, (October 1958). 11 pp. Alphabetical listing by trade names; includes properties and applications.

PRODUCTION

HOT-SIZING TITANIUM SHAPES AT RYAN AERONAUTICAL CO. C. O. Herb. *Mach.*, (October 1958). 3 pp. Description of equipment, methods, and applications of this process.

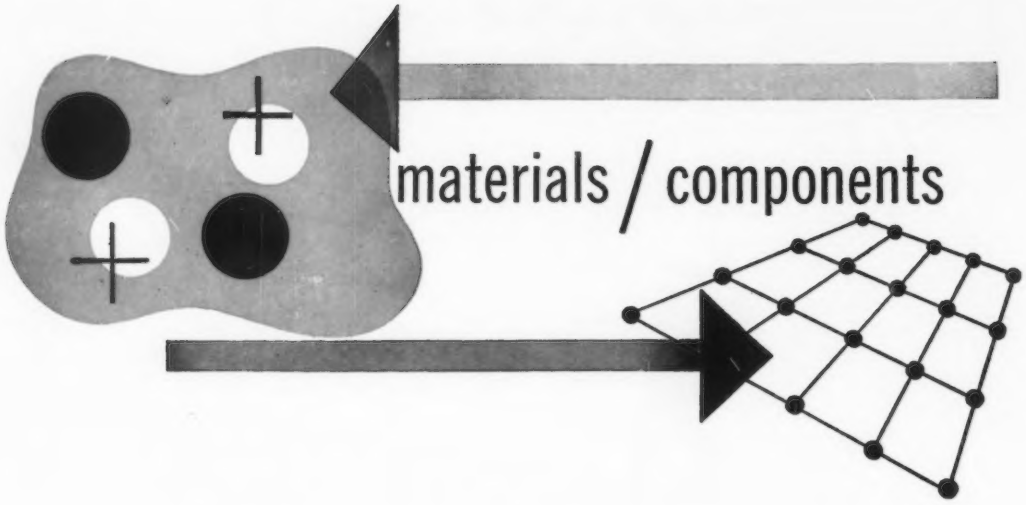
FOLLAND GNAT. *Acft. Prod.*, (September 1958) 7 pp. Assembly tooling for light-fighter production amplified with illustrations.

WHICH CLAMPS ARE BEST FOR JIGS AND FIXTURES? F. Strasser. *The Iron Age*, (October 2, 1958). 4 pp. 27 types of clamps are illustrated, and advantageous applications are discussed.

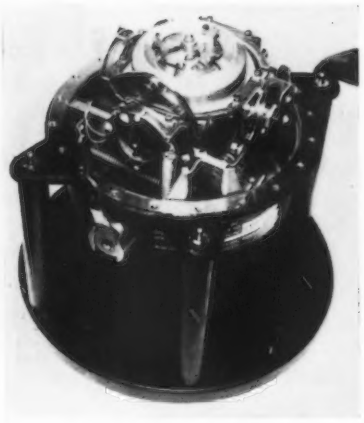
REVIEWED IN THIS ISSUE

Periodicals and Papers

Acft. Prod. Aircraft Production (British)
Aerop. The Aeroplane (British)
AHS Newsltr. American Helicopter Society Newsletter
Av. Wk. Aviation Week
Des. News. Design News
Flight Flight (British)
Iron Age The Iron Age
Mach. Machinery
SAE Journal Society of Automotive Engineers Journal
Space-Aero. Space Aeronautics
Tool Engr. Tool Engineer



AIR JETS HOLD GYRO IN POSITION



A vertical gyroscope designed especially for drone aircraft applications is being produced under the designation N3200A.

It is a two-axis, cageable model constructed of welded, wrought, non-magnetic stainless steel to withstand shocks and vibration. It conforms to military specifications MIL-C-7436A, "Control, Roll and Pitch, Electrically Driven, Vertical Gyro Operated, Type K7."

The gyro is maintained in vertical position by the precessive action of air jets. Air is supplied by a blower attached to the rotor motor.

Potentiometers are provided on pitch and roll axes to indicate displacements from vertical.

Iron Fireman Mfg. Co., Electronics Div.

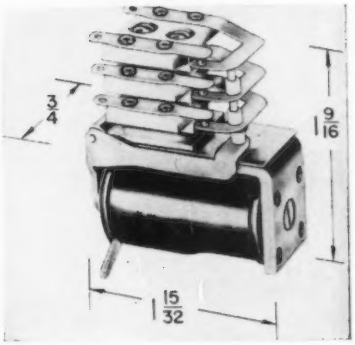
Circle 30 on postcard for more data

NEW DESIGN JET TIRES USED ON LATEST F-106

A new type of aircraft tire is shown during engineering flight tests of Convair's F-106 at Edwards AFB. The 30-8.8 tire, with "dimpled" tread design, will be standard equipment on Convair's F-106 "Delta Dart." Tire has outlasted other jet tires five to one, according to manufacturers' tests.

B. F. Goodrich Co. Aviation Products Div.

Circle 39 on postcard for more data



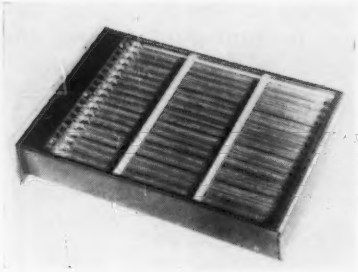
CERAMIC INSULATION REDUCES CAPACITANCE

A miniature telephone type relay has ceramic spacers and pushers to minimize intercontact capacitance to levels which permit switching signals of several megacycles. Capacitance ratings are 1.5 mmf between contacts in an open relay, 6.0 mmf between contacts, and 4.0 mmf between contacts and case in a sealed relay.

The relay is equipped with palladium contacts rated for 1 amp at 115, 60 cycle resistive loads. For low level switching, gold alloy contacts are available. Contact arrangements up to dpdt or 3pst can be furnished.

Potter & Brumfield, Inc.

Circle 32 on postcard for more data



FILM-TYPE ELEMENTS HEAT ELECTRA PROP JET

Low weight film type heating elements are used to heat the cabin of Lockheed's Prop-Jet Electra.

A complete cabin heater unit, ready for installation, weighs only 17 lbs, delivers 19 kw with a maximum air pressure drop of only .35"H_2O.

Elements operate to 500°F or 40 watts/ sq in. and are .015 in. thick. They are stable and meet MIL-E-5272A.

Therm-O-Lab

Circle 31 on postcard for more data

TELEMETRY TRANSMITTER COVERS 215 TO 260 MC

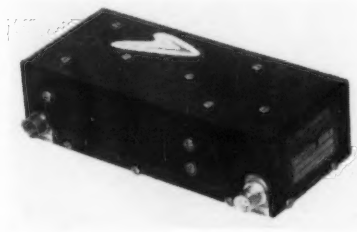
Type 1004A miniaturized FM telemetry transmitter provides true frequency modulation across the standard IRIG telemetry channels and completely covers the telemetry frequency band of 215 to 260 mc.

The carrier frequency is crystal stabilized in a unique manner. True frequency modulation is obtained by impressing the input signal through a semiconductor circuit.

Weight, 22 oz. Size, 5⅞ x 2 11/16 x 1 11/16 in. Mounts direct to flat heat-sink surface.

Tele-Dynamics Inc.

Circle 41 on postcard for more data



DYNAMIC SEALS SERVICEABLE TO 700°F.

By using compatible metals and carefully determined interferences and finishes, a new rod or piston seal performs up to 700°F and 4000 psi.

Developed for advanced aircraft hydraulic components, the new seals use no elastomers, 0-rings, or gaskets.

Navan Products, Inc.

Circle 35 on postcard for more data

"VITON A" SEALS USABLE IN FUELS, HYDRAULICS

O-rings and other seals, molded from Vitron A base material for service with jet fuel and hydraulic oils at very high temperatures, are now being offered.

The new material can withstand long-term use at 500°F in compatible fluids and has a limited life at 600°F. It is suitable for static seals at 40°F.

Parker Seal Co.

Circle 36 on postcard for more data

CERAMIC DISCS CHANGED BY ELECTRICAL FIELD

Thin, flat modified barium titanate ceramic discs have the property of changing dimensions in a predictable fashion when an electric field is applied to them. They are being used in sonar research by the Navy. Varying in diameter from 2 to 3 in., the electrostrictive ceramic discs are only a few thousands of an inch thick.

Discs are also used in electromechanical transducers, in the manufacture of non-magnetic audio speakers, and in advanced research and development work in the field of electronics. The discs provide enough motion to operate as loud speaker drivers, providing direct conversion of electrical energy into forceful movement.

Mullenbach Div.
Electric Machinery Mfg. Co.

Circle 28 on postcard for more data

GUIDANCE GYRO BEARING USES PLASTIC RETAINER

A bearing retainer providing improved lubrication and reducing oil mass shifts has been developed for inertial guidance gyros.

Known as Nysorb, this new retainer precludes errors induced by shifting oil masses.

Minimizing oil mass shifts was solved by designing a retainer from a sintered nylon powder impregnated with an instrument oil. The plastic retainer holds sufficient lubricant in its pores to operate the bearing at high speed.

Barden Corp.

Circle 34 on postcard for more data

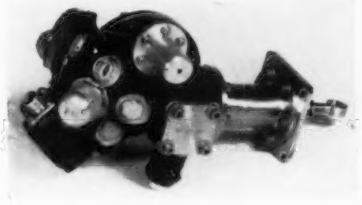
THRUST CONTROL UNIT SENSES DEVIATIONS

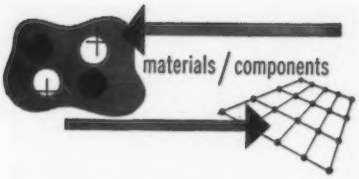
This hydromechanical unit is designed to sense and correct small errors in thrust chamber pressure in liquid-propellant rocket engines.

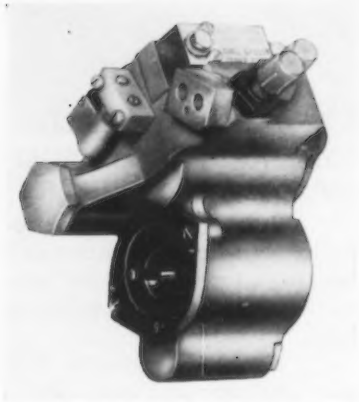
The controller has a two-stage pressure regulator for obtaining an accurate reference, a high gain pressure error sensing diaphragm, and a two-stage hydraulic amplifier. Accuracy and load insensitivity are obtained by well-known servomechanism techniques.

Bendix Products Div.
Bendix Aviation Corp.

Circle 27 on postcard for more data







HYDRAULIC POWER PACK USED AT NEGATIVE "G"

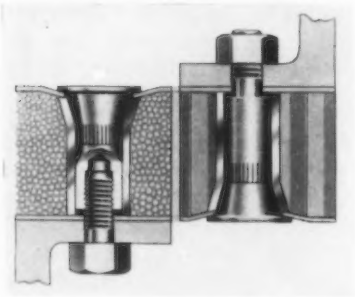
Known as Model E/H 110, Type 200, an hydraulic power pack receives mechanical shaft power at 12,000 rpm and delivers 0.6 gpm against a discharge of 2000 psi, when pumping MIL-O-5606 oil.

The pump utilizes a compensating bellows to adjust for thermal expansion of the oil and to permit operation of the pack at any attitude or altitude and under severe negative "G" loading.

Eastern Industries, Inc.

Circle 33 on postcard for more data

STRUCTURAL FASTENER FOR SANDWICH PANELS HAS VERSATILE DESIGN



The new fastener for sandwich panels consists of two pre-assembled parts: the body and the expanding sleeve.

The body section is available in many forms, including internal threaded, threaded stud, male rivet and thru-bolt types. Flush applications with minimum dimple are assured on both skins through die action of body and sleeve.

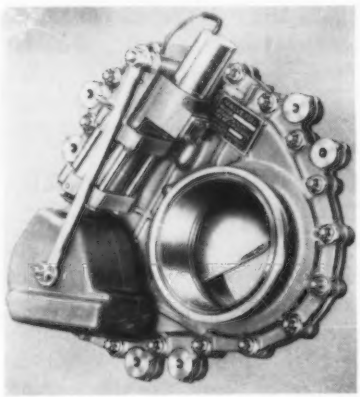
The fastener is conveniently retained in panel by a splined interlock which also prevents rotation. If threaded body is damaged in handling of panel, it can be removed and replaced.

The Delron Co.

Circle 29 on postcard for more data

GATE VALVES FOR CYROGENIC APPLICATIONS

Gate valves for the handling of liquid oxygen and other cyrogenics can be utilized under operating line pressures up to 60 psi and ambient temperatures ranging from —320 to 250°F.



Valve actuation can be accomplished manually, electrically, hydraulically, or by pneumatic pressure.

Valves can also be used for handling standard fuels.

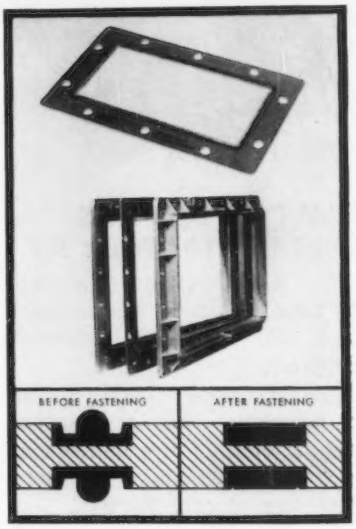
Koehler Aircraft Products Co.

Circle 43 on postcard for more data

WAVE GUIDE SEALS PREVENT R/F LEAKAGE

A line of wave guide seals which provide no-leakage fluid sealing, prevent R/F leakage and eliminate burning and/or arcing, is being marketed.

Called Electr-O-Seals, the new seals are made to fit EIA (RETMA) standard guides and provide savings by making special machining of flanges unnecessary. The inside metal



mating edges of the seal are knurled to assure positive electrical contact. They are also reusable.

Parker Seal Co., Div. of Parker-Hannifin Corp.

Circle 37 on postcard for more data

SMALL CHECK VALVE USED IN PNEUMATICS

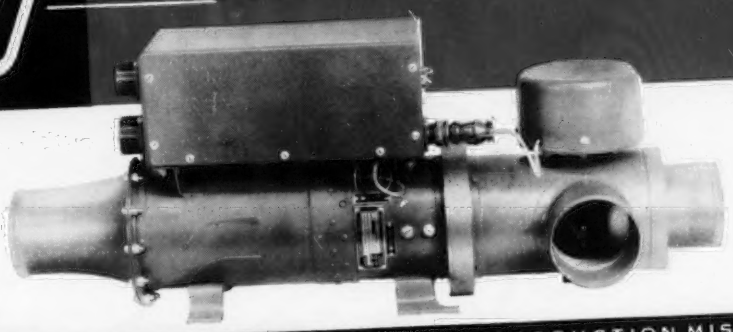
A 1½ in. check valve is designed to withstand the forces caused by rapidly reversing high temperature, high pressure air surges.

Constructed of 17-4PH stainless steel, the unit weighs 0.4 lb. Maximum internal leakage is 0.05 lb per min at 150 psig and 800°F. The lightweight valves will withstand 10 vibration.

Barber-Colman Co., Aircraft Controls Div.

Circle 42 on postcard for more data

D&B HEATER-BLOWER-AIR VALVE PACKAGE UNITS



NOW SUPPLYING HEATED AIR TO GUIDANCE SYSTEMS OF PRODUCTION MISSILES

FEATURES

- ALL COMPONENTS THERMOSTATICALLY CONTROLLED
- DELIVERS—180 CFM AT 5.0 IN. OF WATER
- LENGTH—25 IN. DIAMETER—4.25 IN. WT.—17# MAX.
- SOLENOID OPERATED AIR VALVE
- 28 VOLT D.C. POWER

Let us hear about your needs

D&B RESEARCH

DEAN & BENSON RESEARCH INC.

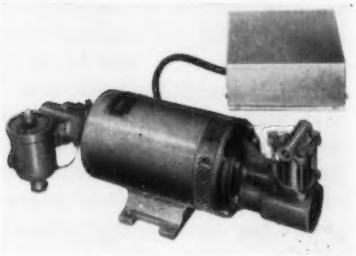
16 RICHMOND STREET CLIFTON, NEW JERSEY

GREGORY 1-1600

Circle 9 on Inquiry Card, page 81

PREFLIGHT TESTER FOR PRESSURE INSTRUMENTS

Lear-Romec unit designed primarily as a missile or aircraft instrument pre-flight tester, consists of double ended



motor driving an oil-free air compressor and an oil-wetted rotary vacuum pump.

The unit will deliver 450 cipm of free air at 30 psi gage discharge pressure and operate with pressures up to 65 psi gage.

The vacuum pump uses silicon oil as the wetting agent and has an ultimate vacuum of 0.20 in. hg abs.

Lear Inc., Lear-Romec Div.

Circle 38 on postcard for more data

VOLTAGE CALIBRATOR HAS ¾% ACCURACY

A new Type 100 Voltage Calibrator is designed for accurate calibration of oscilloscopes, AC or DC voltmeters, and measurement types of test equipment.

Main feature of the Type 100 is the ¾% accuracy of the directly metered DC or symmetrical 1 KC square-wave output.

Exact Electronics, Inc.

Circle 26 on postcard for more data

GERMANIUM TRANSISTORS MADE AVAILABLE

Two new series of switching P-N-P alloy junction germanium medium power and power transistors.

Both series have a low 0.25 ohm R_{cs} in addition to a maximum 125 microampere collector cutoff current at one half rated breakdown voltage.

The four units in each series have voltage ratings of 40, 60, 80, and 100 respectively, and identical switching characteristics.

Texas Instruments Inc.

Circle 40 on postcard for more data

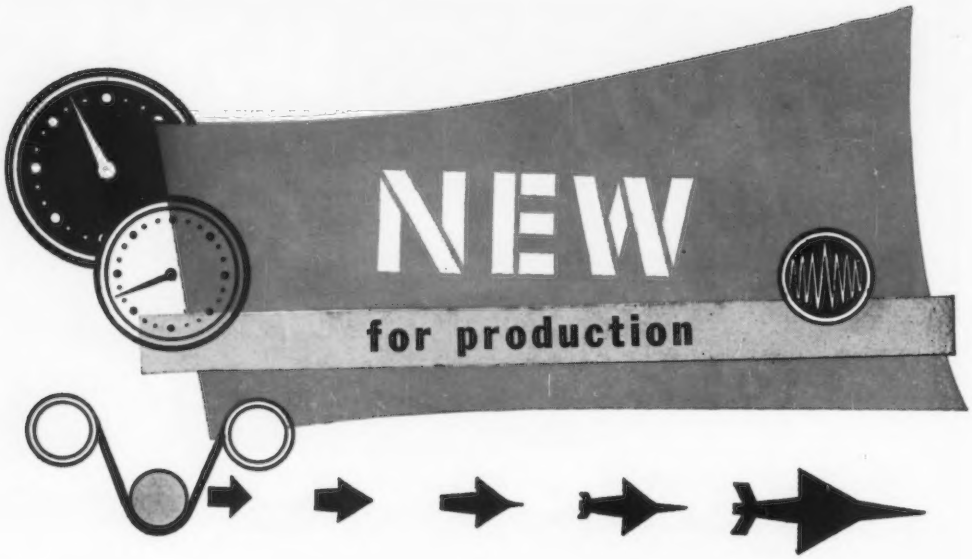
PRESSED SHAPES FROM BERYLLIUM OXIDE

Hot pressed and machined beryllium oxide shapes designed for nuclear, aircraft and missile, and electronics industries are now in production.

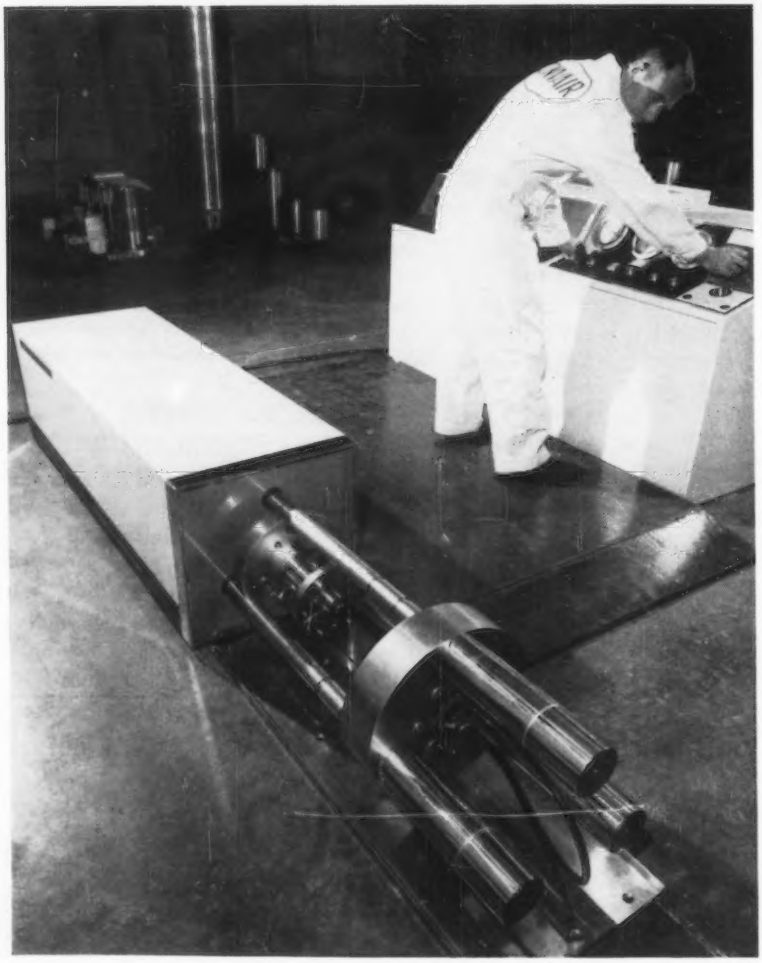
Beryllium oxide shapes or powder are being used for radiation windows, high temperature thermocouples and a number of research applications including re-entry studies. Electronics applications include Klystron and ceramic tube parts, antenna window applications, airborne radar antenna and other parts.

Beryllium Corp.

Circle 25 on postcard for more data



METALWORKING MACHINE EMBODIES NEW HIGH-VELOCITY TECHNIQUES



"Dynapak" machine tools are a breakthrough in a new metalworking field. They apply a technique which uses high pressures to move materials in the fluid state.

These high velocity, high-energy-rate "captive tornado" machines can be applied to forging, forming, extruding, compacting, shearing, and blanking of metals and other materials.

The technique may lead to parts needing no additional machine shaping. Velocities can be controlled to within one or two ft per sec. Hence, optimum forming parameters may be established for precise repetitive production.

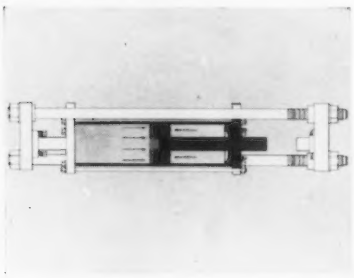
Many metals—including high-strength, high-temperature steels—flow as if they were plastic when worked at high velocities, energy, and pressures.

Model 600 includes a heavy dynamic reaction plate (held by three tie bars) which positions the die. Piston reacts against die with tremendous

velocity and pressure. It is controlled with one dial on console.

Model can produce 40,000 ft lb of energy at velocities over 200 ft per sec. It is two ft wide, nine ft long and two ft high, weighing 3,000 lb. Four bolts fasten machine down. Models 1200 and 1800 produce 160,000 ft lb and 360,000 ft lb respectively. A fourth machine with 36 in. cylinder bore produces 1,500,000 ft lb.

Sketch illustrates age-old principle of pneumatics here employed. High pressure gas is stored in chamber, left. Relatively low gas pressure in chamber



at right forces piston against orifice plate. With a balance of pressures maintained, machine is "set for firing." When high pressure gas is allowed to push against entire face of piston, overbalance causes it to move at velocities as much as 2,500 ft per sec.

Smaller and lighter than most machine tools with same function, Dynapak is based on the HYGE actuating mechanism developed for missile shock testing.

The technique may allow greater latitude among design engineers in creating structural elements. Likewise, simplified dies and tooling are possibilities. A $3 bottle of nitrogen compressed to 2,000 lb per sq in. will operate unit for a day. Mechanisms are of 4340 and 4130 heat-treated chrome steel alloys, hard chrome plated.

Convair Div.
General Dynamics Corp.

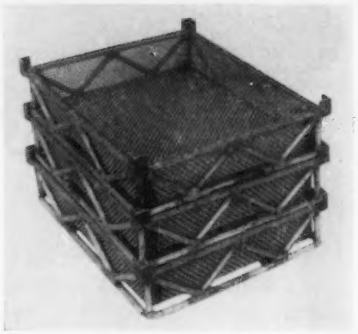
Circle 48 on postcard for more data

STACK BASKETS USED TO HEAT-TREAT PARTS

Stack baskets, designed for surface furnaces, provide up to eight compartments for treatment of small parts during heat-treating operations.

Baskets provide separate compartments for different parts. In the case of contract shops, they allow division of parts according to client.

Fitted with special stacking lugs, baskets can be placed, in two stacks of four, into the furnace. Measurements of each basket are 16½ in. x 21½ in. x 4 in. deep with a framework of ½ in. diam rods. Mesh is No. 4 weave made of .080 in. wire.



Stacking lugs are 1 in. x 1 in. x 1/3 in. angle. Baskets are made of Incoloy for longer life and resistance to high temperature.

Wiretex Mfg. Co.

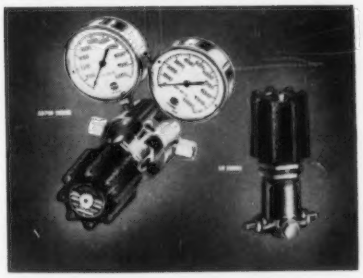
Circle 44 on postcard for more data

NEW REGULATORS CONTROL WIDE PRESSURE RANGE

Two new regulators control high pressure gases to 7,000 psi, with operating ranges from —67° to 200°F.

The GD700 series consists of a primary regulator (a "Gas-O-Dome" type), controlled by a relief venting high pressure spring-loaded regulator. Used for testing pneumatic components in missiles and aircraft, it has two inlet pressure ranges: to 3,600 and 7,000 psi.

The LR series loading regulators will hold dead end pressures without leakage even



if the main source of supply pressure has failed. Designed for low capacity testing (2 scfm max.) of components, series has max. inlet pressure of 7,000 psi.

Victor Equipment Co.

Circle 49 on postcard for more data

CLEARANCE COMPARATOR FOR PRECISION PARTS

Checking the clearances between the ID and OD of mating parts to millionths is now possible with three-station ID-OD clearance comparator. Equipment checks precision mechanisms, such as servo valves, where clearances are kept to a few millionths of an inch.

Comparator combines two standard Model G—or Super G—"Air-O-Limit" gaging units (one ID and one OD) plus a computing circuit. Output of the ID and OD units is fed into a multifunction computing relay. Clearance or interference between the two parts is read on the clearance indicator in the center of the gage.

Clearance indicator may have double the magnification of the other two indicators.

Pratt & Whitney Co.

Circle 47 on postcard for more data

continued on next page

ULTRASONIC CLEANER FOR INDUSTRIAL USE

First industrial size high power ultrasonic cleaning system to be mass-produced in the U.S.A. is Series 5000 SonBlaster.

Series consists of the powerful 40-kc, 500-watt output Model G-5001 generator and a giant size, 10-gallon-capacity transducerized cleaning tank. It's capable of one minute or less high speed precision cleaning of large assemblies or parts as well as large loads of smaller components.

Model G-5001 generator may be used to energize as many as ten submersible transducers adapted to existing tanks.

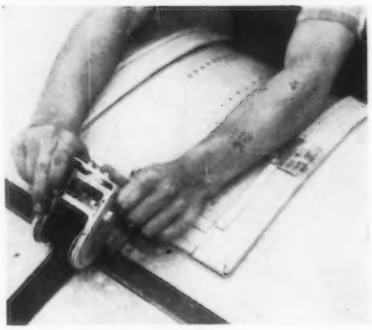
Narda Ultrasonics Corp.

Circle 46 on postcard for more data

TIE-DOWN BUCKLE HAS HIGH STRENGTH

Tie-down headaches in production and transportation are eased with 27 oz "Ratchet Buckle."

Buckle, which has 5000 lb breaking strength, is used with a suitable webbing strap. It holds assemblies steady after



strap is fed between two spacer bars and pulled to take up slack. A handle on the unit tightens strap by rotating center spool 60 deg against a ratchet.

Tension is released by depressing the release bar and pulling handle back.

Loads up to 500 lb three times as much as with conventional buckles may be applied to the strap with the 5000 lb-breaking strength buckle.

General Logistics Div.
Aeroquip Corp.

Circle 45 on postcard for more data

ALL THE PRODUCTION YOU'LL EVER WANT — ALL THE PRECISION YOU'LL EVER NEED

BUT MY WORK INCLUDES THE MANUFACTURE OF—

I KNOW! AND YOU CANNOT POSSIBLY BUY A BETTER MACHINE FOR THE JOB THAN—

THE HAMILTON No. 1-B PRECISION SMALL GEAR HOBBING MACHINE

INVESTIGATE IT! YOU'LL SEE!

SPUR GEARS, WORM GEARS, and SPIRAL GEARS (up to 6" O.D.)
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SPECIAL TOOTH FORMS
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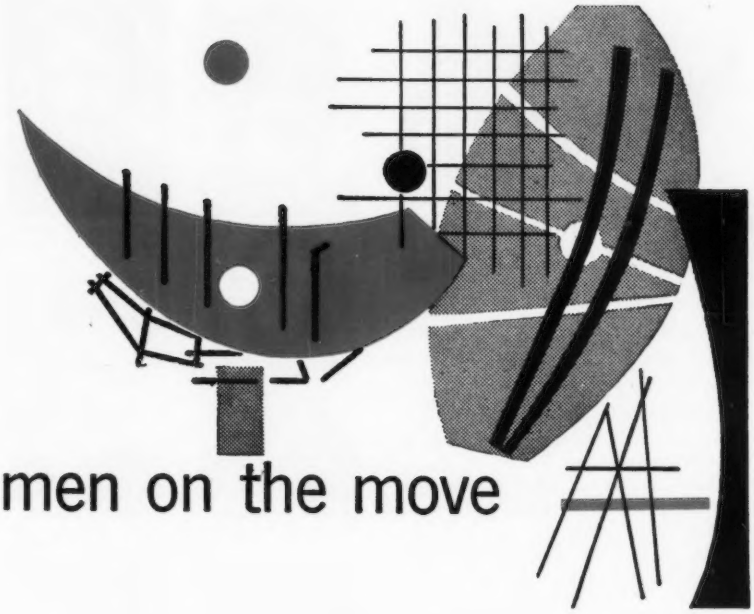
THE HAMILTON TOOL COMPANY · 882 SOUTH NINTH STREET · HAMILTON, OHIO

Circle 10 on Inquiry Card, page 81



men on the move

DR. SIMON RAMO, returned to duties as executive vice president, Ramo-Wooldridge Corp. DR. LOUIS G. DUNN, succeeded Dr. Ramo as president of Space Technology Laboratories, now a separate corporation. Dr. Dunn also named to board of directors of STL. DR. RUBEN F. METTLER, STL vice president; JAMES T. BROWN, vice president of Mellon National Bank; and SAMUEL E. GATES, New York attorney, were named to board of directors of STL.

JOSEPH W. FRAZER, former president of Kaiser-Frazer and of Willys-Overland, has come out of retirement to help form the Custer Frazer Corp.

LAURANCE U. HURLEY, named coordinator of test operations, Astro Div., Marquardt Aircraft Co. JOHN W. CRESSE, named supervisor of new project management group in Astro's nuclear operation.

MAX D. LISTON, appointed director of engineering; THOMAS V. PARKE, director of product standards; EARL C. JANSON, director of manufacturing, at Beckman Instruments Inc.

JOHN H. HUNT, elected a vice president, Stavid Engineering Inc. DR. RAYMOND K. MASNAGHETTI, promoted to manager of Research and Analysis Dept., Development Div.

J. P. LAWLER, promoted to vice president, Aeronca Mfg. Corp.

D. CARL BUCK, named asst. chief metallurgical engr., U.S. Steel Corp.

F. W. LOWRY, named sales manager, space technology section, Westinghouse Electric Corp.

EDWARD R. ARNOLD, named technical service representative, Defense Products Dept., Callery Chemical Co.

HARRY H. GOODE, appointed technical director of the Systems Div., Bendix Aviation Corp. GERALD C. SCHUTZ has joined technical staff of Dr. R. D. O'Neal in the Systems Div. J. M. MILLER, named director of engineering, Missile Section. MARVIN E. WASPE, promoted to plant manager, Cincinnati Div.

NORMAN K. WARNER, appointed general manager, Transport Engineering Div., Potter Aeronautical Corp.

C. E. MAHONEY and J. L. RICHARDSON, named assistant secretaries of Ryan Aeronautical Co., Electronics Div. HANDS M. SCHIFF, appointed operations manager, Ryan's Torrance, Calif. plant.

T. A. WILSON, named program mnager at Boeing Airplane Co. for the firm's assembly and testing of Minuteman ICBM.

D. R. GERO, appointed vice president and general sales manager, G. M. Giannini & Co.

LEIGH V. HOWLETT, named product engineer for Thor, Regulus, and other military programs at Flint plants, AC Spark Plug Div of General Motors. DON C. STEWART now coordinates the new beryllium gyro program at AC Spark Plug.

EDWARD C. EBELING, appointed manager of central region customer services of Government Products Group, American Machine & Foundry Co. MANSFIELD D. SPRAGUE, elected vice president for public and industrial relations. JOSEPH E. MULHEIM, appointed general manager of AMF's new Leland Electric Aircraft Products Div.

RICHARD C. CROUCH, named president and treasurer of Cal-Tronics Corp., a division of Acme Precision Products Inc. ROBERT J. CALVERT, appointed general manager.

THURMAN C. ERICKSON, appointed assistant manager, Subsystems Div., Servomechanisms Inc.

JAMES H. CARMICHAEL, elected corporate vice president, Commercial Transport Div., Fairchild Engine & Airplane Corp.

continued on next page

T. A. Wilson
Boeing

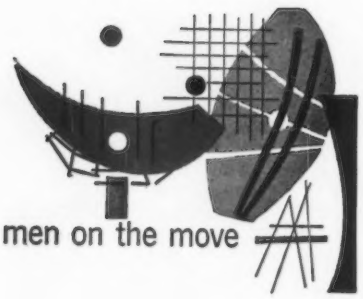
D. R. Gero
G. M. Giannini

Joseph E. Mulheim
American Machine & Foundry Co.

Robert J. Calvert
Cal-Tronics

Thurman C. Erickson
Servomechanisms

James H. Carmichael
Fairchild



LT. GEN. DONALD L. PUTT, RET. elected president, United Research Corp., subsidiary of United Aircraft.

W. H. SEIBERT, named manager of support services dept., AiResearch Manufacturing Div., Garrett Corp. G. E. IRWIN, named manager of contract administration. R. J. TATGE, named assistant sales manager, ROBERT W. MORRIS, appointed manager of foreign operations dept.

FORREST G. HOGG, appointed resident area representative, Motorola Military Electronics Div.

WILLIAM G. EVANS, named general purchasing agent, Convair Div., General Dynamics Corp.

HUGH E. WEBBER, appointed manager of Ground Systems at The Martin Co.'s guided missile and electronics center, Orlando, Fla. MAJ. GEN. FREDERICK R. DENT, JR., USAF (RET.), appointed manager, Engineering Projects Dept., Baltimore Div.

GERHARD NEUMAN, appointed general manager of General Electric's Small Aircraft Engine Dept., Lynn, Mass. DONALD C. BERKLEY, named general manager of Jet Engine Dept., Evandale, O.

MILO K. HENRY, named manager of Denver regional office, Military Products Group, Minneapolis-Honeywell Regulator Co. CLYDE W. KAERICHER, named director of administration for MH's inertial guidance plant in St. Petersburg, Fla.

WALTER L. TANN, named special assistant to vice president and general manager, Aerojet-General Corp. WILLIAM C. HOUSE, director Aerojet Systems Div., has been granted one year of absence to serve with Advanced Research Projects Agency. DR. WILLIAM O. WETMORE, appointed special asst. to the vice president, Azuza Operations.

EDWARD L. BRAUN, named director of systems and electronics, Genesy's Corp. J. B. RAWLINGS, named controller.

Lt. Gen. Donald L. Putt (ret.) United Research

Col. James W. Anderson Jr. USAF (ret.) Magnavox

Robert W. Morris AiResearch Mfg. Div. Garrett Corp.

Nelson G. Spoth Kolcast Industries Div. Thompson Products Inc.

Forrest G. Hogg Motorola

D. J. Sanchini Rocketdyne

Maj. Gen. Frederick R. Dent Jr. USAF (ret.) Martin

Felton H. Havins Anadite

Milo K. Henry Minneapolis-Honeywell

Sheldon P. Smith Douglas

Edward L. Braun Genesys Corp.

Philip W. Scott Budd

COL. JAMES W. ANDERSON, JR. USAF (RET.), named general manager, Urbana, Ill. Div. of Magnavox Co.

MAJ. J. RILEY FOWLER has assumed duties as Air Force Officer-in-Charge, Cessna Aircraft Co.

A. J. RIZZI, appointed comptroller of Stratos Div., Fairchild Engine and Airplane Corp.

ROBERT P. DODDS, appointed sales engineer, Aero Hydraulics Div., Vickers Inc.

NELSON G. SPOTH, named manager, Kolcast Industries, Div. of Thompson Products. EDWARD P. RILEY, named supervisor of automotive divisions, Thompson Products Inc. of which he is a vice president. JAMES H. COOLIDGE becomes chief fiscal officer, Thompson Ramo Wooldridge Inc.

D. J. SANCHINI, now serves as assistant program manager in guiding the Air Force-sponsored E-1 and F-1 programs involving high-thrust liquid propellant rocket engines at Rocketdyne, div. of North American Aviation Inc.

CHARLES E. HUNTER, appointed special assistant to president Thiokol Chemical Corp. J. W. ANTONIDES, appointed assistant general manager, Reaction Motors Div. ROBERT M. LAWRENCE, appointed assistant secretary. THOMAS H. JOHNSON JR., is new director of administration. JOHN H. SIMS, named chief engineer in charge of Rocket Engineering Dept., Longhorn Div. of Thiokol.

FELTON H. HAVINS, named director of sales engineering, Anadite, Inc.

DR. HAROLD C. WEBER of M.I.T., appointed chief scientific advisor consultant to the Army's chief of research and development.

SHELDON P. SMITH, general manager of Douglas Aircraft's Charlotte, N. C. Div., has been made a vice president of the firm.

WALTER W. TANGEMAN has retired as chairman of the board, Cincinnati Milling Machine Co. He continues as a director of the firm. FREDERICK V. GEIER, president since 1934, was elected chairman with responsibilities of chief executive officer. SWAN E. BERGSTROM was elected president.

PHILIP W. SCOTT, elected group vice president, The Budd Co., supervising operations of the Nuclear Systems Div.

Perchlorates

Brochure gives aims, progress of ammonium perchlorate and lithium perchlorate research.

Hef Inc.

Circle 70 on postcard for more data

Phosphating Analysis

Special kit enables metalworking manufacturers to determine whether their products are adaptable to phosphating.

Turco Products Inc.

Circle 71 on postcard for more data

Burroughs Brochures

Two brochures. First shows early and latest techniques in electrographic printing and recording. Second is on radar data processing for SAGE with explanation of air defense system.

Defense Sales Div.
Burroughs Corp.

Circle 52 on postcard for more data

Platinum Products

Digest of precious metals and chemicals produced by firm. Notes on care of platinum.

J. Bishop & Co.

Circle 73 on postcard for more data

Facilities Brochure

36-page brochure covers main departments of power supply system manufacturer.

Sundstrand Turbo

Circle 54 on postcard for more data

Data Recording

Pictoral review of Datasync electronic - optical data recording equipment with synchronized, sometimes multi-language read-out.

Berndt-Bach Inc.

Circle 57 on postcard for more data

Special Purpose Alloys

New bulletin on alloys for tubing and pipe used in aircraft, missile and nuclear field.

Carpenter Steel Co.
Alloy Tube Div.

Circle 51 on postcard for more data

Kanigen

Bulletin 258 on electroless nickel alloy-Kanigen.

General American
Transportation Corp.

Circle 67 on postcard for more data

Cold Extrusion Products

Description of cold extrusion of metals, and equipment used.

Cold Extrusion Products Div.
Central Foundry Co.

Circle 75 on postcard for more data

Aerodynamic Flow

Brochure shows firm's designing and manufacturing of optical and mechanical components for aerodynamic flow vizualization.

Tinsley Laboratories Inc.

Circle 50 on postcard for more data

Facilities

Brochure shows precision production of sheet metal.

Castle Industries Inc.

Circle 76 on postcard for more data

Flight Line Heaters

Explosion - proof flight line heaters for aircraft described in bulletin.

Coates Electric Mfg. Co.

Circle 64 on postcard for more data

Fasteners

Illustrated catalog with detailed technical data on H-K fasteners.

Western Sky Industries

Circle 62 on postcard for more data

Battery and Power Plugs

Revision of catalog with specs, outline of function of plugs.

Cannon Electric Co.

Circle 74 on postcard for more data

Engineering Brochure

8-page engineering brochure details engineering services and capabilities, highlighting production of nuclear fuel elements.

Corning Nuclear Corp.

Circle 53 on postcard for more data

Plastics

Eleventh revision of "A Ready Reference For Plastics"; non-technical book on plastics including background, properties, design.

Boonton Molding Co.

Circle 72 on postcard for more data

Metal Fabrication

Brochure describes precision metal-fabricating facilities of Missile-Air Div.

U. S. Chemical Milling Corp.

Circle 60 on postcard for more data

Lubricants & Wear

Lubrication newsletter covers effect of lubricants on the "wear in" of new machinery.

Alpha-Molykote Corp.

Circle 69 on postcard for more data

Precision Instruments

Catalog presents the line of ultra-precision instruments and complementary accessories with manufacturing applications.

Engis Equipment Co.

Circle 65 on postcard for more data

Manufacturing Picture

Illustrated "Blueprint for Manufacturing" shows facilities and operation of aircraft-missile subcontractor.

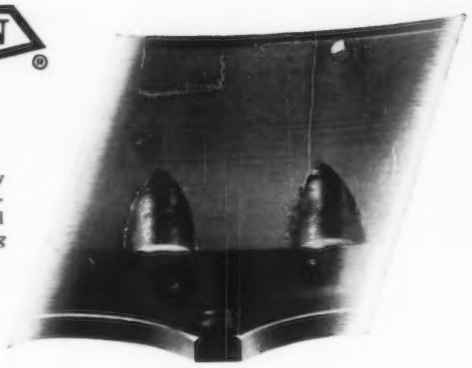
Twin Coach Co.

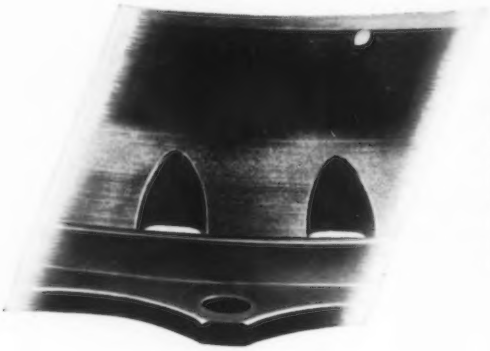
Circle 61 on postcard for more data

continued on next page

OSBORN®

BEFORE BRUSHING
Jet engine part formerly hand-filed and emery-rubbed to remove burrs and sharp edges. *Hand-finishing time: 45 minutes.*

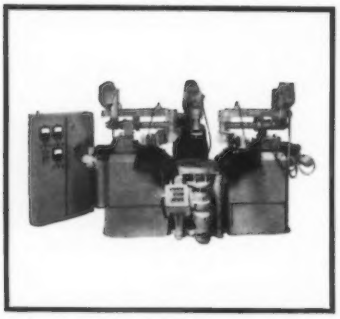




AFTER BRUSHING
Burrs thoroughly removed... edges and surface junctures blended to 6-8 microinches. Each part precision-finished quickly, uniformly. *Osborn Brushamatic® finishing time: 6 minutes.*

6 minutes to microfinish this jet engine part!

...it's 7½ times as fast with OSBORN Brushamatic® Methods



THESE JET ENGINE PARTS are microfinished at low cost, automatically—at high production rates on Osborn Brushamatic® 51-3L Machine. Three Osborn Fascut® brushes (with compound) operating at 1750 rpm do the job.

IT used to take 45 minutes to hand-finish this precision jet engine component. *Today, this leading jet engine manufacturer does the job in just 6 minutes with Osborn Brushamatic® Methods. It's 7½ times as fast and results in significant dollar savings.*

Slow hand-finishing still left scratch marks to cause possible stress fractures. But, rapid Brushamatic® finishing produces a *precision 6 to 8 microinch surface* . . . automatically removes burrs . . . blends sharp edges and surface junctures.

Result: a fast, economical, precision Brushamatic® finish that reduces stress concentration areas. Uniform, high-quality parts are produced at high production rates.

It's typical of how Osborn Power Brushing works to help you speed production . . . cut costs . . . improve product quality. An **Osborn Brushing Analysis**, made in your plant at no obligation, will show you how. Write or wire us for details —and for your copy of the 20-page Brushamatic® booklet. *The Osborn Manufacturing Company, Dept. AM-1, Cleveland 14, Ohio.*

Osborn Brushes

BRUSHING MACHINES • BRUSHING METHODS
POWER, PAINT AND MAINTENANCE BRUSHES • FOUNDRY PRODUCTION MACHINERY

Lockheed & Space

Illustrated brochure shows Lockheed's history and space capabilities.

Lockheed Aircraft Corp.
Missile Systems Div.

Circle 68 on postcard for more data

Aircraft Hardware

First three sections available of aircraft hardware manual containing specs on most items of hand hardware used in aircraft.

Adams-Rite Mfg. Co.

Circle 63 on postcard for more data

Ductile Vanadium

Brochure on high purity vanadium metal.

Vanadium Corp. of America

Circle 78 on postcard for more data

Gas Welding

Illustrated catalog covers all phases of gas welding and cutting business. Spec. sheets included.

Harris Calorific Co.

Circle 79 on postcard for more data

Process Instruments

52-page catalog on process instruments.

Fischer & Porter Co.

Circle 66 on postcard for more data

Jet Cleaners

8-page bulletin, "Sellers Hydraulic Jet Cleaners," describes modern cleaning equipment.

Sellers Injector Corp.

Circle 56 on postcard for more data

Carbide Drills

Solid cemented carbide miniature drills, reamers and end mills as small as 0.024-inch diam. featured in catalog.

Super Tool Co.

Circle 58 on postcard for more data

Turret Drills

Bulletin illustrates, describes 6 and 8 spindle automatic hydraulic or tape controlled turret drills, plus accessories.

Burg Tool Mfg. Co.

Circle 59 on postcard for more data

Capsular Elements

Bulletin AV2001 gives information, material and performance specifications of ⅞ in. capsular elements.

Bristol Company
Aircraft Components Div.

Circle 55 on postcard for more data

Thermocouples

Catalog describes thermocouple line.

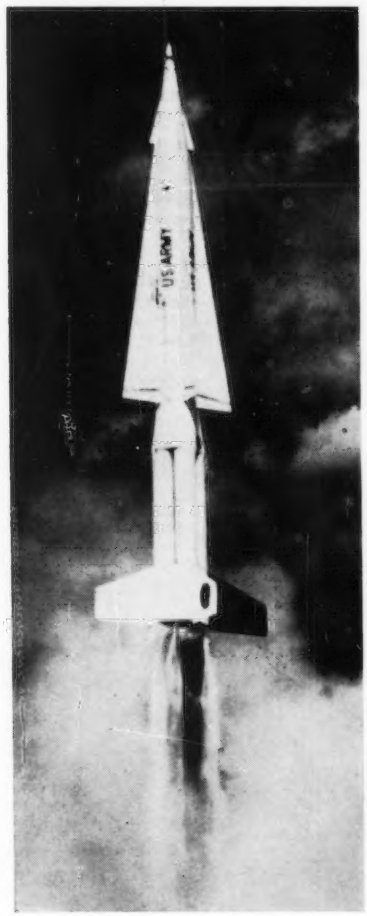
Aero Research Inst. Co.

Circle 77 on postcard for more data

industry notes

Douglas production: Hercules meets a master

U. S. Army Nike Hercules missile soars skyward powered by cluster of four solid propellant boosters.



Nike Hercules, dart-shaped anti-aircraft missile, is produced on an assembly-line basis from special missile-geared facilities at Douglas Aircraft's Charlotte Division.

Douglas, principal subcontractor and producer, is accomplishing possibly the largest major missile output in the U. S. Factory, on a 77 acre site, is a complex of almost barrack-like buildings which Douglas Aircraft operates for Army Ordnance.

Douglas turns out most parts of the Hercules air frame as well as the ground handling and launching equipment. (Prime Contractor, Western Electric Co., is mass producing the equipment.) The fast, ultra-precise job on the missile is done virtually "from the ground up."

Primary material is aluminum sheet for the skins of wings and body sections. (Aluminum and magnesium castings are used for most body frames and aluminum forgings for higher stressed members. Alloy steel is used in the hardware and some attached fittings.)

Large presses blank out the sheet for nose cone and body. The tapering cone offers one of the most ticklish problems. Three men work a press brake with a round nose punch and a V die. Moving the small diam end slowly and the large diam end rapidly beneath the hammering punch, they form a "true" three dimensional piece. A bulging die, also used for cones, brings cones to precise tolerances by pneumatic action.

Body and fin skins of Hercules are drilled and riveted to extremely close tolerances in a sub-assembly building. Techniques include an automatic drilling fixture, developed by company engineers, placing a set of holes at exact spots on missile body section in one operation.

Inching almost imperceptibly through the final assembly building, a conveyor line bears the nose cone and main engine section through the specialized touches of cabling and control component experts. Previously, hydraulically actuated control fins were temporarily placed on the back portion of the body, and given an extensive final checkout for simulated flight conditions.

continued on next page

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of advanced
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Circle 12 on Inquiry Card, page 81

industry notes

Hercules

Hercules, now painted white, meets a final plant rendezvous with special shipping containers. Missile goes out on flat cars, is put together completely at the launching site.

The solid propellant missile was first produced a year ago as improvement over Nike Ajax, which has been phased out of production except for spare parts. Hercules has been operational since June of this year, and is bolstering the SAGE system of detection and defense.

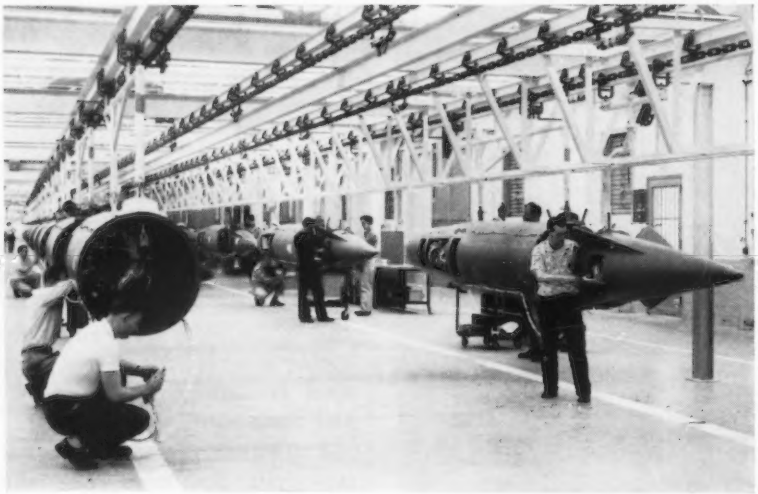
Overall supervision for Hercules belongs to the Rocket and Guided Missile Agency of the U. S. Army Ordnance Missile Command. Besides Douglas, with its 2150 Charlotte Div. employees, hundreds of other subcontractors supply everything from electronic components to bits and pieces like screws and pins.

Hercules specs:

Type: surface to air. Length: 27 ft. Length with four boosters: 41.5 ft. Diam: 32 inches. Weight (including boosters): 10,000 lb. Range: over 75 nautical miles. Guidance: radio command.

Employee does "inside job" laying bead of weather sealing compound along edge of motor support frame. Four bores on aluminum casting frame are attach points for the main wing spars.

Near end of final assembly line, specialists place special cabling in frame. Guidance system allowing remote control from ground is supplied by prime contractor, Western Electric Co.

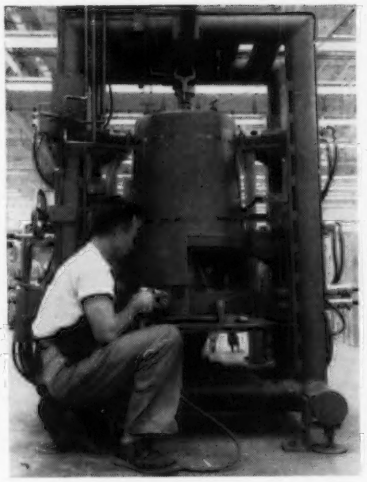


Meets A Master... continued

The government provided about $11-million worth of machine tools and equipment for the facility, officially designated the Charlotte Ordnance Missile Plant.

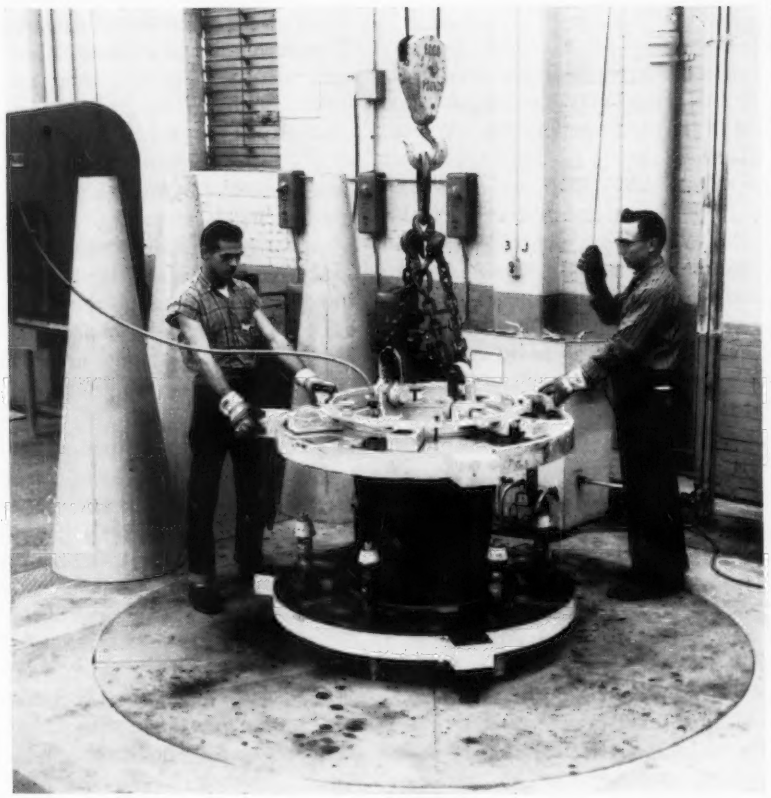
Machinery includes a 1,000-ton blanking press with a 14-inch bed; 1,500-ton hydraulic forming press; 6,000 psi air compressor system; continuous "flow-coating" system.

Nike Zeus, with capabilities against ICBM's as well as aircraft, will eventually replace Hercules production. Development of Zeus is going ahead at full speed.



Automatic drilling fixture is one of the special devices used in Hercules mass production. Here it is used on aft missile body section in subassembly building.

Special bulging die brings section of nose cone to perfect dimensions. Douglas system consists of placing die over aluminum cone, then bringing cone to exact configuration by pneumatic action.



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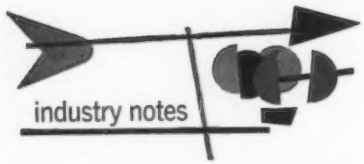
TERRA-SCOPE



Infrared photographic device developed by Barnes Engineering Co. and Army Engineer Research and Development Laboratories may be used in night reconnaissance.

•

Defense Air Transportation Administration has allocated 237 long-range civil air transports to the 1960 Civil Reserve Air Fleet. Included are 18 Boeing 707 jets. Aircraft will be placed under operational control of the Military Air Transport Service.

•

Philco Corp. has received a $2.5-million Army contract for its picture radar system producing clear ground maps from behind clouds or darkness. "Helisphere" radar antenna developed by Westinghouse Electric Corp. scans sky in complete circle without moving itself.

•

New beacon signalling system developed by Bendix-Pacific Div. of Bendix Aviation Corp. allows instrument contact for refueling operations between jets and jet tankers.

•

"Lobber," system of delivering supplies by ballistic cargo missile, has been developed for the Army by Convair Div., General Dynamics Corp.

•

Decrease in flight test hours may result from hydraulically controlled in-flight flutter test system developed by Electro-Systems Inc., Burbank, Calif.

•

The Franklin Institute, Phila., Pa., is working on promising advanced concepts for more efficient nuclear-powered aircraft and satellites.

Reaction Motors Div. of Thiokol Chemical Co. has successfully fired a pre-packaged liquid rocket engine of about 50,000 lb thrust.

•

Ultraviolet-sensitive tube developed by Research Center of Minneapolis Honeywell Regulator Co. simultaneously detects fire, smoke, and combustible vapors; breakthrough should permit development of more efficient fire and explosion warning systems.

•

Named by Air Force as associate prime contractor for Minutemen ICBM assembly and tests—Boeing Airplane Co.

•

Man's initial leap into outer space may come from an ice pack at north or south pole. These are believed the only escape hatches in the radiation band encircling earth.

•

Navy's Bullpup, produced by Martin, may be adapted to Air Force use as the "White Lance."

•

Japan is building 42 P2V Neptune aircraft for its Maritime Self Defense Force. About 60 technicians from Lockheed Aircraft Service Overseas Inc. are assisting Kawasaki Aircraft Co. Arrangement follows agreement between U. S. and Japanese governments.

•

Army lunar probe vehicle will be the relatively untried four-stage Juno missile. Juno uses Jupiter first stage and slightly modified Jupiter C upper Stages. NASA has given the Army authorization for 2 lunar probes and 1 scientific earth satellite attempt. Attempt, in which Army puts highly touted success record on the line by departing from basic Redstone configuration, is slated for early December "when moon and missile are ready."

•

Eighth Explorer satellite, scheduled for February, will contain instrumentation developed by unique company- sponsored organization for basic research, Martin-supported RIAS Inc. Already preceded by ballon studies in August, satellite aims at more specific information about radiation belt discovered by Explorer 3.

•

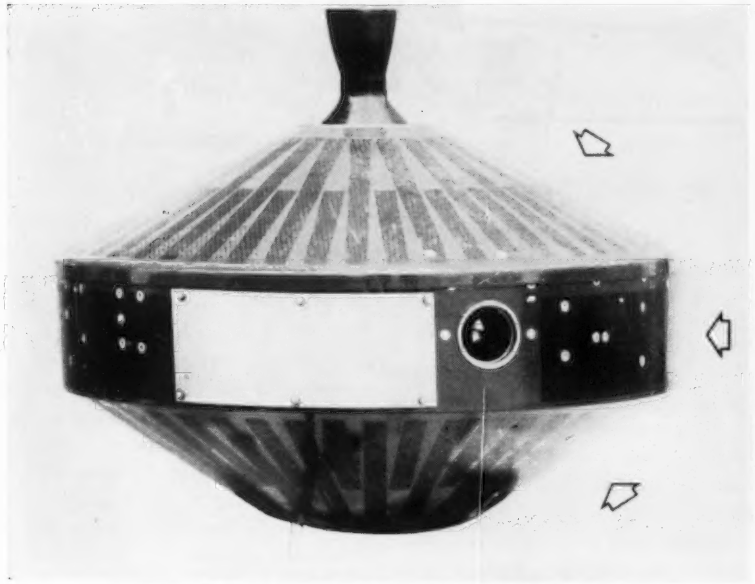
Largest percentage (26 per cent (of the 342 Unidentified Flying Object reports investigated by the Air Defense Command between Jan. 1-July 31 turned out to be "astronomical," presumably comets, etc. Other intelligence evaluations by per cent: aircraft, 22.2; balloons 14.9; miscellaneous (hoaxes, birds) 21.1; insufficient data, 14. Percentage of "unknown" origin, steadily declining, is now 1.8.

•

British blind-flying-and-landing technique attracting attention holds aircraft to center of a magnetic field induced by cables along landing strips. Radio altimeter in plane automatically adjusts rate of descent.

•

The Canadian Government is accenting missile in its air defense system; Bomarc taking a big place. The CF-105 "Arrow" aircraft is not being put into production now, and development of the Astra fire control system and the Sparrow missile have been terminated. Substitution of U. S.-made fire control in the Arrow marks closer integration of U. S.-Canadian design, development, and production of defense equipment.



PIONEER I USED PLASTIC HONEYCOMB

Reinforced plastic honeycomb, used in radomes all the time, has been tagged for the moon.

About eight square feet of the special honeycomb made up most of the body of the 85 lb first moon probe satellite package—"Pioneer I."

Total honeycomb weight: less than 15 oz.

The plastic honeycomb, reinforced with fiberglass, was supplied in sandwich form. This has an extremely high strength-to-weight ratio.

Two other factors went into selection of the fiberglass-reinforced plastic:

Low dielectric properties. This ability to allow transmission and reception of radio signals was essential in the data-collecting venture.

Insulating and heat resistant properties. Manufacturer of the honeycomb took place in the Berkeley, Calif., plant of Hexcel Products, Inc. Fiberglass cloth, impregnated with resins, was supplied to Hexcel by the Coast Manufacturing Co., Livermore, Calif.

After the honeycomb itself was made at Hexcel, it went through another resin impregnation process to further increase strength and density. Then the honeycomb sandwich went to Summit Industries, Gardena, Calif., to be molded to final form.

SCIENCE SAILING INTO SPACE

Sails may have a function in the solar system. Recent speculation envisages "solar sailing," using the pressure of light on a sail to propel a space-ship.

Once the sailboat was placed in orbit by rocket, the idea goes, sail could be unfurled. The energy of photons from the sun would then cause orbit to become larger until the sail and space ship escaped gravitation. Then it would become a solar satellite, spiraling around the sun.

Most schemes call for a sail of very thin plastic sheet no more than 0.001 inch thick. One side of this would be aluminized to permit reflection of light. Aluminizing would theoretically double the pressure from the light.

For navigation scientists would simply turn the mainsail by ground controls.

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Applied Research in Radome Development, Antenna Development, Infrared, and Acoustics.

Please write to: Mr. L. M. Stevenson, Engineering Personnel, North American Aviation, Los Angeles 45, California.

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new Bruhn-Schmitt Book on Aircraft Structure Design

From the pen of the recognized authority . . . E. F. Bruhn, Purdue University, and assisted by A. F. Schmitt, Convair Astronautics . . . comes Volume I, 1958 Edition, *ANALYSIS AND DESIGN OF AIRCRAFT STRUCTURES . . . Analysis for Stress and Strain*, previously published under the title of *ANALYSIS AND DESIGN OF AIRPLANE STRUCTURES*. This new volume deals primarily with stress and strain analysis of statically determinate and statically indeterminate structures common to aircraft construction. Presentation of theory is followed by over 150 problem solutions. Use of matrix methods in the stress analysis of highly redundant structures is treated in considerable detail. Postpaid anywhere in the U. S. for $8.75.

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Circle 14 on Inquiry Card, page 81

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TORQUE TESTING FIXTURE

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LABORATORIES and for
PRODUCT CONTROL
in assembly.

Capacities: (0-200 in. lbs.) or (0-150 ft. lbs.)

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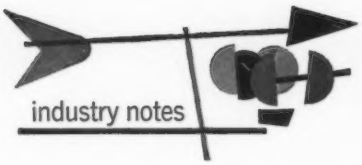

TECHNICAL PROSPECT

After over a year's research, Republic Aviation has developed hydraulic systems able to stand 1,000°F. They must still be perfected to function below freezing. One of the systems uses Tungsten Carbide balls for valves. Republic is investigating feasibility of sapphires for valves. Inconel X, high-strength, mostly-nickel alloy, replaces steel springs. Republic is working with a new synthetic fluid, polyphenyl ether, which is expected to retain its properties over entire 20-1,000° range.

•

Chemical milling is being applied to wall-thickness-reduction of castings. Chemical Contour Corp. named Howard Foundry Co. as license to use its chem mill process — originally developed for sculpturing aluminum sheet and plate — to aluminum and stainless steel alloy castings.

•

Full-scale production of liquid fluorine, high energy oxidizer for rocket fuels, is now underway at the new Metropolis, Ill., facility of Allied Chemical's General Chemical Div.

•

New light-weight thrust cylinder, fairings, and nacelles fabricated by Convair (Fort Worth) Div. of General Dynamics Corp. increase range of Atlas ICBM by about 100 miles. Thrust cylinder sheet and certain formed metal parts are tapered by dynamic etching (Chemical milling). Booster section is lightened by about 500 lb.

•

Electric insulation with supersonic applications has been developed by Westinghouse Electric. It is used in an electric motor operating continuously and sealed inside an oven at 950°F. Insulation and binders are made of inorganic materials.

•

New titanium alloy MST 881, produced by Mallory-Sharon Metals Corp., is viewed as super-alloy, highly temperature resistant, devoid of most impurities, and light.

•

Alcoa has developed a thermo-mechanical means of reducing internal stresses caused by quenching aluminum shapes after heat treatment. Method relieves internal stresses by superimposing system of thermal gradients opposite those which created stresses.

•

Shell Oil has developed "ETR grease H" for space vehicles, aircraft, and missiles. Corrosion resistant, it has operating range from −100°F to +600°F.

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Circle 20 on Inquiry Card, page 81

Five Saab-35 (J35A) Draken supersonic single-seat all-weather jet fighters at Saab's airfield in Linkoping, Sweden. The two closest are production models. Drakens will be used in Sweden's air defense.

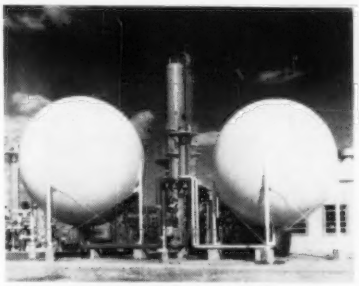
PLANT WILL PRODUCE HIGH ENERGY FUEL

Tonnage quantities of high-energy liquid fuel are expected in 1959 from the recently-dedicated $38-million plant operated for the Navy at Muskogee, Okla., by Callery Chemical Co.

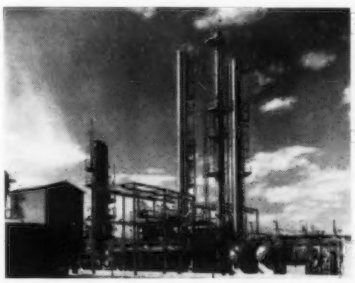
The "HiCal" fuel is slated to be used extensively in tests on propulsion systems such as those in turbo-jets and ram-jets.

Production is from four basic materials — sodium, boric acid, hydrogen and ethylene. Boron is shipped to Muskogee as boric acid, processed to produce diborane, the basic building block for boron-based fuels. In further processing, boron hydride is combined with carbon and hydrogen to produce HiCal.

Basically, the plant consists of four processing units. A massive steam plant provides thermal capacity to bring reactions to create high energy components. A gas plant supplies large quantities of nitrogen, which serves as a protective atmosphere throughout the processing. Many of the chemicals used in producing the fuel would explode on contact with air.



Sphere on the left stores pure nitrogen gas at low pressure, while sphere at right is used for low pressure storage of pure carbon dioxide gas. Tower in the background separates carbon dioxide from nitrogen.



This unit performs the first step in the production of HiCal high-energy fuel. Boric acid and other raw materials are converted here into an intermediate chemical used in the production.

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Minimum requirements are actual experience plus B.S. and advanced degrees in E.E. and Physics.

For more information please write to: Mr.L. M.Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 45, California.

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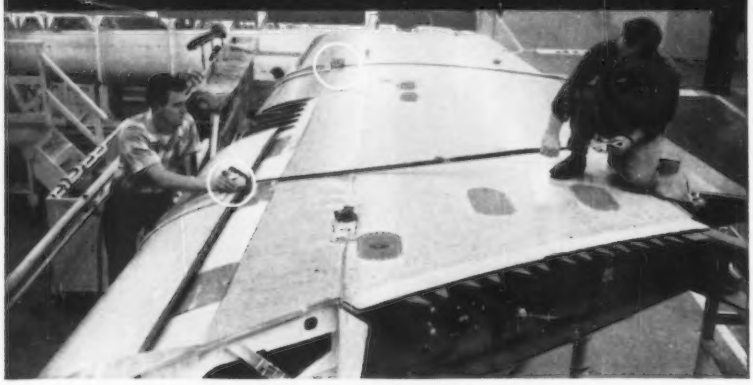
Circle 16 on Inquiry Card, page 81

Versatile Ratchet Tie-Down Buckle Speeds Manufacturing, Simplifies Shipping

FOR DOUGLAS AIRCRAFT COMPANY



At Douglas Aircraft, components of an A-3D Bomber wing section are positioned with the Aeroquip Ratchet Tie-Down Buckle.

The Aeroquip Ratchet Tie-Down Buckle works like a miniature winch, holds tension.

Tie-down straps using the Aeroquip 5000-lb. Ratchet Buckle permit quick, easy handling of parts and equipment. Operating as a miniature winch, the Ratchet Buckle can introduce strap tension up to 500 lbs. manually. Used with any length webbing, it allows infinite strap adjustment and quick release. Also available in 10,000 lb. model. Mail coupon below for full details.

Transporting a disassembled Douglas A-4D Bomber is simplified by using Aeroquip Ratchet Tie-Down Buckles to secure components.

General LOGISTICS

A DIVISION OF Aeroquip CORPORATION

2929 Floyd Street, Burbank, California AMM-12

Please send me ☐ full details on Ratchet Tie-Down Buckle ☐ complete new General Logistics catalog.

Name_____

Title_____

Company_____

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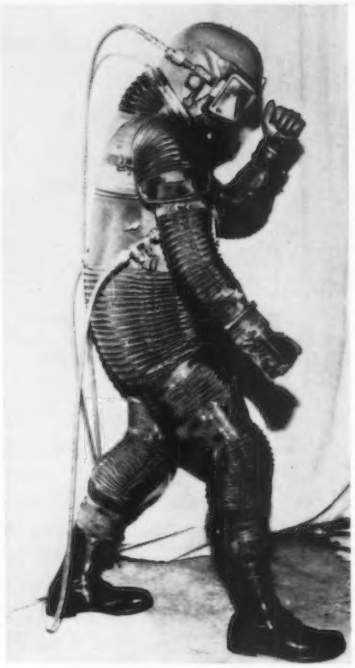
industry notes

BEATING THE HEAT



Men working inside refractory fabricating plant to be built in 1959 will wear these air-tight "space suits." Plant, to be built for the Navy at Bridgeville, Pa., by Universal Cyclops Steel Corp., will fabricate molybdenum and other metals in an inert atmosphere. Hot working range: 3000°F to 5000°F. Intake and exhaust lines on air conditioned suits connect to manifolds.

PENNSALT PRODUCING AMMONIUM PERCHLORATE

Production of ammonium perchlorate, used in high energy solid state missile propellants, is proceeding at Portland, Ore., plant of Pennsalt Chemicals Corp.

Unit is next to firm's sodium chlorate facility which supplies basic chemical for ammonium perchlorate.

Ammonium perchlorate acts as the oxidizer when used in solid state rocket fuels.

DETAILS OF HUSTLER'S NAVIGATION SYSTEM

Sperry Gyroscope's bombing - navigation system for the Convair B-58 Hustler is one of the most complex units ever produced by the firm.

Unit, which has exceptionally close tolerances, is 36 inches high, 36 inches wide and 55 inches long. It contains 1,850 structural parts. The array of electronic equipment is mounted in racks fabricated from magnesium and then inserted in a magnesium structure contoured to the B-58's fuselage.

Practically all the parts are fabricated from either magnesium AZ31B sheet or ZK60A extrusions — some 40 different extrusions are used in all.

The high strength ZK60A, with typical compressive yield strength of 36,000 psi in T5 condition at room temperature, is non-weldable. Rivets and mechanical fasteners (7,000 in all) are therefore used throughout the unit.

Total weight of the Hustler component: about 80 lb.

Unit includes several honeycomb panels consisting of aluminum honeycomb sections and magnesium spacers between layers of magnesium sheet. Most magnesium components are manufactured at Sperry's Nassau, N. Y., plant.

Unit, of doppler-inertial type, as installed in the B-58.

Bombing-navigation unit with men from Sperry manufacturing methods and engineering departments who created it. Twenty per cent lighter and 37 per cent more compact than former systems, unit uses magnesium as major structural material.

STANDARD MODELS

Floor model can be separate marking station or integrated into production line.

•

Hand held portable model can be taken to any location with air and electricity.

•

Inspector's gun-type model ideally suited to small part marking.

Hundreds of successful applications have proven the Airgrit's ability to mark delicate electronic parts permanently, gently and fast. A short blast (often less than ½ second) is all that's needed to produce a permanent, "etched" mark on delicate parts or hard to mark surfaces such as glass, plastic, steel or anodized aluminum.

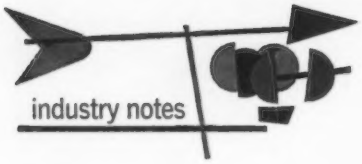
Write today for Bulletins C-25 and C-26, giving complete information on the full line of these remarkable units, or send a sample to be Airgrit marked.

JAS. H. MATTHEWS & CO.

3920 FORBES AVENUE **PITTSBURGH 13, PA.**

OFFICES IN PRINCIPAL CITIES • WRITE, CALL OR TWX PG 424

Circle 17 on Inquiry Card, page 81



INDUSTRY STATISTICS

Source: Bureau of the Census and Civil Aeronautics Administration.

NUMBER AND VALUE OF CIVIL AIRCRAFT SHIPMENTS

	Units		Value in Thousands	
Month	1958	1957	1958	1957
January	579	584	$ 62,311	$ 48,431
February	510	523	65,046	49,278
March	697	675	35,133	46,636
April	704	657	47,496	57,980
May	622	672	35,113	84,136
June	589	590	25,455	69,497
July	503	525	41,587	70,649
August	471	519	30,776	62,990
September	399	466	24,401	54,911
October	.....	474	.....	45,687
November	.....	516	.....	47,213
December	.....	544	.....	44,856
Total—Year	.....	6,745	.....	$682,264
Total—9 Mos.	5,074	5,211	$367,318	$544,508

AIRFRAME WEIGHTS OF CIVIL AIRCRAFT SHIPMENTS

	Thousands of lbs.		Avg./Aircraft	
Month	1958	1957	1958	1957
January	1,909.9	1,574.9	3,299	2,697
February	1,891.4	1,554.0	3,709	2,971
March	1,313.2	1,625.6	1,884	2,408
April	1,606.4	1,886.6	2,282	2,871
May	1,293.4	2,558.0	2,079	3,806
June	1,068.1	2,114.0	1,813	3,583
July	1,418.7	2,096.0	2,820	3,992
August	1,106.0	1,950.6	2,349	3,758
September	855.2	1,641.1	2,143	3,522
October	.....	1,456.5	.....	3,073
November	.....	1,480.8	.....	2,870
December	.....	1,430.8	.....	2,630
Total—Year	.....	21,368.9	.....	3,168
Total—9 Mos.	12,462.3	17,008.0	2,456	3,264

SHIPMENTS OF PISTON ENGINES FOR CIVILIAN AIRCRAFT

	Units		Value	
Month	1958	1957	1958	1957
January	1,033	920	$ 8,883,000	$ 12,445,000
February	1,139	902	9,696,000	13,596,000
March	994	1,010	8,174,000	13,975,000
April	881	950	8,174,000	14,388,000
May	828	1,020	6,176,000	15,160,000
June	783	933	5,994,000	15,636,000
July	730	801	4,898,000	12,748,000
August	693	776	3,420,000	8,603,000
September	757	728	3,312,000	10,150,000
October	.....	921	.....	13,638,000
November	.....	878	.....	9,880,000
December	.....	1,020	.....	12,237,000
Total—Year	.....	10,859	.....	$152,456,000
Total—9 Mos.	7,838	8,040	$ 58,727,000	$116,701,000

TOTAL HP. OF AIRCRAFT PISTON ENGINE SHIPMENTS FOR CIVILIAN USE

	Total Hp. (in Thousands)		Avg. Hp. per Engine	
Month	1958	1957	1958	1957
January	459.9	604.4	445	657
February	518.2	647.0	455	717
March	440.7	679.2	443	672
April	428.0	668.2	486	703
May	338.3	715.8	409	702
June	328.7	730.4	420	783
July	282.1	590.4	386	737
August	210.0	425.6	303	548
September	213.1	482.8	282	663
October	.....	628.3	.....	661
November	.....	473.0	.....	539
December	.....	586.2	.....	575
Total—Year	.....	7,231.3	.....	666
Total—9 Mos.	3,219.0	5,543.8	411	690

EMPLOYMENT IN THE AIRCRAFT AND PARTS PLANTS

	Complete Aircraft Plants		Aircraft Engine and Parts Plants		Aircraft Propellers and Parts	
Month	1958	1957	1958	1957	1958	1957
January	457,500	533,800	156,600	185,200	20,800	19,700
February	455,300	540,300	154,000	188,400	20,600	20,100
March	457,800	541,200	152,400	189,200	20,300	20,400
April	456,600	541,300	152,300	188,400	19,800	20,600
May	445,500	542,800	151,600	184,800	19,300	20,500
June	454,200	541,000	151,700	184,000	18,800	20,700
July	453,200	539,100	151,400	182,100	17,900	21,000
August	.....	528,100	.....	178,200	.....	20,500
September	.....	515,900	.....	174,900	.....	20,600
October	.....	503,700	.....	170,600	.....	20,700
November	.....	477,000	.....	163,200	.....	20,200
December	.....	463,900	.....	160,200	.....	20,400
Avg.—Year	.....	522,300	.....	179,100	.....	20,500
Avg.—7 Mos.	454,300	539,900	152,900	186,000	19,600	20,400

UNFILLED ORDERS OF AIRCRAFT FOR CIVILIAN USE

Month	1958	1957
January	732	997
February	707	992
March	684	985
April	670	966
May	660	947
June	654	900
July	705	854
August	693	808
September	673	783
October	.....	757
November	.....	782
December	.....	761

readers' orbit

Needs High-Load, High Temp Bearing

. . . The Controls and Accessories Division of this company is currently engaged in a program which necessitates the use of heavily loaded ball and roller bearings and spur gears operating dry at 1200°F. Consequently your article, "Non-metallic Bearings" in the September issue was of great interest to us.

We would appreciate your supplying us with the names of other companies and government agencies conducting research in this field, plus any information you may have on the work they are doing. It is believed that an exchange of information would prove mutually advantageous in solving the complex problems involved.

Because of the high unit loads in our current program, we are primarily interested in the metallic materials, although non-metallic materials may be considered in future applications.

Your help will be greatly appreciated.

A. J. Kreiner
chief engineer
controls and accessories
Marquardt Aircraft Co.

New Departure reports they are doing work on wet and dry bearings operating at these temperatures. Although many people think that temperatures above 1000°F automatically call for dry bearings, New Departure does not concur. Contact Mr. Lee Cobb, Bristol, Conn.

SKF Ind. reports they are working on special materials for applications similar to the ones you describe, results are still inconclusive. Contact Mr. J. C. Bowman, 790 Tennessee, San Francisco, SKF West Coast Manager.

Timken is no doubt doing similar work but eds. had no specific contact there.

Anti-Friction Bearing Mfg. Assoc., 40 E. 42nd Street, N. Y. 17, is an excellent source of information in these matters, as is Metal Mfg. Assoc., 1218 Chestnut Street, Phila. 7. WADC, Wright Patterson AFB, would know of any projects that are receiving government backing for high-temperature, high-load bearings.

Information can also be obtained from T. Barish, Jack & Heintz, Inc., C. H. Bailey, Shell Devel. Co., A. S. Irwin, Marlin-Rockwell Corp., C. L. Dellinger, Norma-Hoffman Bearings Corp., R. S. Barnett, Texaco Research Center, and other individuals and organizations AMM does not have at its fingertips.

Doing a Nice Job, P. S. But . . .

. . . re. your November 1958 issue . . . the article "High Strength Steel" is a pretty good summation of the use of steels—and the growing use of steels in aircraft. . . . We are producers of special alloy steels and . . . will distribute (copies) to our customers and friends . . . both here and abroad.

Roger F. Waindle
president
WaiMet Alloys Co.

P.S. For a magazine doing as well as yours, we dislike to see misuse of descriptive terms . . . re. Ceramic Honeycomb of this same issue. The introductory illustration is erroneously referred to as a "microphotograph"—this should be . . . "photomicrograph" . . . misuse of technical terms detracts a good deal from the value of your offerings.

Eds. could take refuge behind Webster's which indicates the two terms are interchangeable in a loose sense, but prefer reader Waindle's and industry's more precise choice of words. Sharp readers make sharp editors make a sharp magazine.

Have Read—Can Use

. . . have read your article entitled "Before Plating-Peelable Plastic" (Oct., pp. 70). . . . We have reason to believe we might make use of this product. May we please have sent . . . any brochures or literature which would give us more information on this butyrate peelable plastic. Would it be possible to obtain a sample.

L. R. Hendren
process engineer
Grand Central Rocket Co.

Manufacturer (Seal-Peel) advises brochure and sample will be mailed from West Coast warehouse.

Needs Info on Materials

. . . As Materials, Process and Standards Engineer . . . am engaged in establishing a Materials and Process Section for the Maynard Laboratory, designed to be part of the production Engineering Department. This effort will largely encompass evaluation, definition of, and authorization to use materials. In addition, it will define by specification publication, our contract commitments for the use of these materials and apparatus . . . present needs are to establish technical engineering data, catalog and pertinent data files for reference.

Your suggestions, assistance and cooperation would be most welcome.

Thomas E. Baker
mat'ls, process & stds eng.
production eng. dept.
Raytheon Mfg. Co.

Agencies which can assist are too numerous to mention here . . . detailed letter is on the way. Readers who have lived through a similar experience are invited to pass along their wisdom to reader Baker.

Interesting . . . Informative

. . . In your October issue, the article . . . "Personalized Quality Control, by Curt Williams, has particularly drawn my attention . . . can see possibilities of using a similar, modified system in my work . . . would like to take this opportunity to thank you for a very informative and interesting magazine.

W. R. Raymond
quality control analyst
Lycoming Div., Avco Mfg. Corp.

Readers in 28 different companies have expressed a similar interest in "Personalized Quality Control."

◆

december 1-12
national defense resources conference
industrial college of the armed forces
departmental auditorium, washington
"national security factors"

◆

december 1-5
annual meeting
american society of mechanical engineers
statler-hilton and sheraton-mc alpin, n. y., n. y.
"new frontiers in engineering"

december 2-4
third conference on reliable electrical connection
electronic industries assn.
dallas, tex.

◆

december 3
industrial preparedness meeting
american ordnance asso.
waldorf-astoria, n. y., n. y.

◆

december 3-5
eastern joint computer conference & exhibit
bellevue-stratford hotel, phila., pa.

december 3-5
second national symposium on global communications
institute of radio engineers; american institute of electrical engineers
colonial inn, st. petersburg, fla.

◆

december 4-5
ninth national conference
professional group on vehicular communications
institute of radio engineers
hotel sherman, chicago, ill.

◆

december 13-16
visual communications congress
society of reproduction engineers
hotel sherman, chicago, ill.
"research today—product tomorrow"

◆

december 17
22nd wright brother lecture
smithsonian institute, washington, d. c.
maurice roy will discuss french aeronautical research

◆

december 27-30
fifth annual meeting
american astronautical society
hotel statler, washington, d. c.

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Potential Unlimited

This new procedure has solved hitherto unsolvable problems, and greatly increased capacity and quality in virtually every application.

As pioneers in this very "young" development, we can offer you real help in licking hard metal removal problems, with actual installation and performance data. **WRITE TODAY!**

Results depend on the spindle used. There is nothing finer in its field than a STANDARD Super Precision Spindle . . . available for electrolytic application in 50 to 3000 Amperes.

THE STANDARD ELECTRICAL TOOL CO.
Precision Spindle Division
3000 River Road Cincinnati 4, Ohio

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advertiser's products and services
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Exact Electronics Inc.

27 **Control, thrust**
Bendix Products Div.
Bendix Aviation Corp.

28 **Discs, ceramic**
Mullenbach Div.
Electric Machinery Mfg. Co.

29 **Fastener, structural**
The Delron Co.

30 **Gyro, vertical**
Iron Fireman Mfg. Co.

31 **Heater, Electra**
Therm-O-Lab

32 **Insulation, ceramic**
Potter & Brumfield Inc.

33 **Power pack, hydraulic**
Eastern Industries

34 **Retainer, gyro**
Barden Corp.

35 **Seals, dynamic**
Navan Products Inc.

36 **Seals, Viton A**
Parker Seal Co.

37 **Seals, wave guide**
Parker Seal Co.

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Lear-Romec Div.
Lear Inc.

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Aviation Products Div.
B. F. Goodrich Co.

40 **Transistors, germanium**
Texas Instruments Inc.

41 **Transmitter, telemetry**
Tele-Dynamics Inc.

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Aircraft Controls Div.
Barber-Colman Co.

43 **Valves, gate**
Koehler Aircraft Products Co.

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Wiretex Mfg. Co.

45 **Buckle, tie-down**
General Logistics Div.
Aeroquip Corp.

46 **Cleaner, ultrasonic**
Narda Ultrasonics Corp.

47 **Comparator clearance**
Pratt & Whitney Co.

48 **Metalworking, high velocity**
Convair Div.
General Dynamics Corp.

49 **Regulators, high pressure**
Victor Equipment Co.

Alphabetical List of Companies

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General Dynamics Corp.
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45 **General Logistics Div.**
Aeroquip Corp.
Buckle, tie-down

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47 **Pratt & Whitney Co.**
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Regulators, high pressure

44 **Wiretex Mfg. Co.**
Baskets, stack

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Specific Products Manufactured .....

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Postcard valid 8 weeks only. After that use own letterhead fully describing item wanted. **DEC. 1958**

Please send further information on items circled below. ■

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
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281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300

YOUR NAME ..... TITLE .....

COMPANY .....

PLANT ADDRESS .....

CITY ..... ZONE ..... STATE .....

WORTH ASKING FOR

Alphabetical List of Items

50 **Aerodynamic Flow**
Tinsley Laboratories Inc.

51 **Alloys, special**
Carpenter Steel Co.
Alloy Tube Div.

52 **Brochures, Burroughs**
Defense Sales Div.
Burroughs Corp.

53 **Brochure, engineering**
Corning Nuclear Corp.

54 **Brochure, Sundstrand**
Sundstrand Turbo

55 **Capsular Elements**
Bristol Co.
Aircraft Components Div.

56 **Cleaners, hydraulic jet**
Sellers Injector Corp.

57 **Data Recording**
Berndt-Bach Inc.

58 **Drills, carbide**
Super Tool Co.

59 **Drills, turret**
Burg Tool Mfg. Co.

60 **Fabrication, metal**
U. S. Chemical Milling Corp.

61 **Facilities Brochure**
Twin Coach Co.

62 **Fasteners, H-K**
Western Sky Industries

63 **Hardware, aircraft**
Adams-Rite Mfg. Co.

64 **Heaters, flight line**
Coates Electric Mfg. Co.

65 **Instruments, precision**
Engis Equipment Co.

66 **Instruments, process**
Fischer & Porter Co.

67 **Kanigen**
General American Transportation Corp.

68 **Lockheed & Space**
Missile Systems Div.
Lockheed Aircraft Corp.

69 **Lubricants**
Alpha-Molykote Corp.

70 **Perchlorates**
Hef Inc.

71 **Phosphating**
Turco Products Inc.

72 **Plastics**
Boonton Molding Co.

73 **Platinum Products**
J. Bishop & Co.

74 **Plugs, battery & power**
Cannon Electric Co.

75 **Production, cold extrusion**
Central Foundry Co.
Cold Extrusion Prods. Div.

76 **Production, sheet metal**
Castle Industries Inc.

77 **Thermocouples**
Aero Research Inst. Co.

78 **Vanadium, ductile**
Vanadium Corp. of America

79 **Welding, gas**
Harris Calorific Co.

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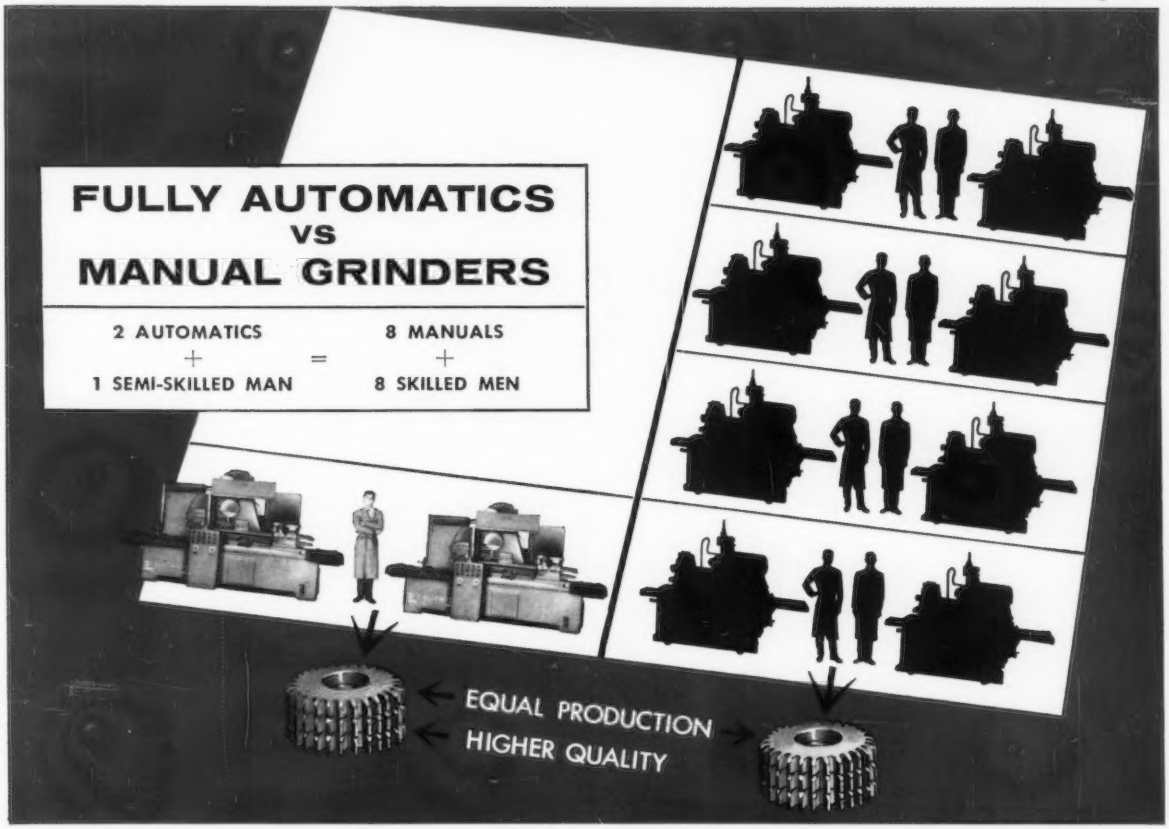


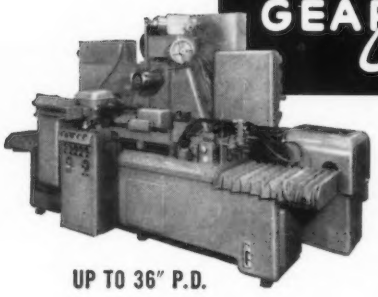
—Plus this 4-way versatility

Choose from any of these cycles with selective feed increments:

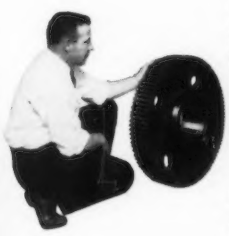
1 Rough grinding
2 Rough grind; finish grind
3 Rough grind; semi-finish grind; finish grind
4 Manual grind

50th ANNIVERSARY—1908-1958

GEARGRIND Detroit



UP TO 36" P.D.



GEAR DATA

No. Teeth	96
Pitch Diameter	26.7"
Diametral Pitch	3.6
Pressure Angle	25°
Face Width	4.5"

FLOOR TO FLOOR PRODUCTION TIME

Single Gear/Arbor	55 min/gear
Two Gears/Arbor	33 min/gear

GEAR ACCURACY

Involute Profile	Within .0002"
Tooth to Tooth Spacing	.0003" max.
Runout of Pitch Diameter	.0006" total
Lead Error	Less than .0001"/"

For all the facts—write today!

THE GEAR GRINDING MACHINE COMPANY

3913 Christopher, Detroit 11, Michigan

Manufacturers of:

RZEPPA ("Sheppa") Constant Velocity Universal Joints 58-MT5A

Circle 2 on Inquiry Card, page 81

SIDEREAL TIME

AT FORD INSTRUMENT CO. WITH THE

BEHLMAN INVERTRON®

Again the Behlman INVERTRON, a completely electronic A. C. Power Source, is in "good company". This time it's with Ford Instrument Co., Division of Sperry Rand Corportion, prime contractor for both the "standard" and Jupiter guidance systems. Famous for advanced research and development facilities, it is only natural Ford Instrument specified the famous Behlman INVERTRON!

Ford Instrument engineer recording data from a simplex time recorder driven by the Behlman Sidereal Time Standard. The data will be used to compute the drift rate of the air bearing gyro on the test stand in left foreground of picture.

A variety of INVERTRON models cover the range from milliwatts to kilowatts, from subsonic to supersonic frequencies and for single or multiphase output. Frequencies may be variable or fixed.

Photograph courtesy Ford Instrument Co., Division of Sperry Rand Corporation.

For further information write or call

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ELECTRONICS • MECHANICS • OPTICS
DESIGN • DEVELOPMENT • PROTOTYPE
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Representatives in all principal cities and Canada

Circle 3 on Inquiry Card, page 81